

Onshore Petroleum Activity – NT EPA Advice

SANTOS QNT PTY LTD – ENVIRONMENT MANAGEMENT PLAN (EMP) FOR THE MCARTHUR BASIN DRILLING PROGRAM NT EXPLORATION PERMIT (EP) 161 (STO2-7)

BACKGROUND

The Minister for Environment and Natural Resources has formally requested under section 29B of the *Northern Territory Environment Protection Authority Act 2012* (NT) (NT EPA Act) that the Northern Territory Environment Protection Authority (NT EPA) provide advice on all Environment Management Plans (EMPs) received under the Petroleum (Environment) Regulations 2016 (NT) (the Regulations).

That advice must include a recommendation on whether the EMP should be approved or not, supported by a detailed justification that considers:

- whether the EMP is appropriate for the nature and scale of the regulated activity to which the EMP relates (regulation 9(1)(b))
- the principles of ecologically sustainable development (regulation 2(a)), as set out in sections 18 to 24 of the *Environment Protection Act 2019* (NT)
- whether the EMP demonstrates that the activity will be carried out in a manner by which the environmental impacts and environmental risks of the activity will be reduced to a level that is as low as reasonably practicable and acceptable (regulation 9(1)(c))
- any relevant matters raised through the public submission process

In providing that advice, the NT EPA Act provides that the NT EPA may also have regard to any other matters it considers relevant.

ACTIVITY

Subject	Description
Interest holder	Santos QNT Pty Ltd
Petroleum interest(s)	Exploration Permit 161 (EP161)
Environment Management Plan (EMP) title	Environment Management Plan McArthur Basin Drilling Program NT Exploration Permit (EP) 161
EMP document reference	STO2-7
Regulated activity	This EMP is a revision of an approved EMP for drilling of exploration and appraisal (E&A) wells at the already-established Tanumbirini and Inacumba well pads within EP161, located approximately 350 km southeast of Katherine, NT. The revision includes an additional horizontal E&A well at each of the Inacumba and Tanumbirini well sites. The revised EMP proposes the establishment of multiple wells at the well pads.

	<p>The specific activities proposed are as follows:</p> <ul style="list-style-type: none"> • drilling of the Tanumbirini-3H well, which will be the third well on the well pad • drilling of the Inacumba-2H well, which will be the second well on the well pad • evaluation of Inacumba-2H and Tanumbirini-3H (including mudlogging, wireline/real-time logging while drilling (LWD), diagnostic fracture injection testing (DFIT), coring) • suspension and/or plugging and decommissioning of Inacumba-2H and Tanumbirini-3H • rehabilitation of the Tanumbirini-3H and Inacumba-2H wells. <p>The regulated activity does not include hydraulic fracturing or production of produced water or flowback fluid, and does not require any new ground disturbance.</p>
Public consultation	Public consultation on the revised EMP was required under regulation 8A(1)(b) was undertaken from 25 November 2020 to 23 December 2020.

NT EPA ADVICE

1. Is the EMP appropriate for the nature and scale of the regulated activity (regulation 9(1)(b))

Information relating to the nature and scale of the regulated activity is provided in the revised EMP in a clear format. The technical works program includes drilling of an additional horizontal well at each of the Inacumba and Tanumbirini well sites within EP161. The Tanumbirini well site is approximately 18 km north-northwest of the Inacumba well site. The deepest section of the Inacumba pilot well is proposed to be decommissioned (under the already approved drilling EMP). The deepest section of the Inacumba pilot well is proposed to be decommissioned (under the already approved drilling EMP). Decommissioning of wells, as may be determined in the future, will be conducted in accordance with the requirements outlined in the *Code of Practice: Onshore Petroleum Activities in the Northern Territory* (the Code).

The revised EMP does not include hydraulic fracturing. No gas, produced water or flow back fluid will be produced and no additional land clearing is required as part of the regulated activities proposed. Rehabilitation of the Inacumba and Tanumbirini well sites sits within the previously approved McArthur Basin Civil and Seismic Program EMP and so rehabilitation in this revised EMP is limited to removal of above ground infrastructure in preparation for comprehensive rehabilitation activities.

A number of well evaluation techniques will be conducted during and/or on completion of drilling at both well sites including mudlogging, logging while drilling, wireline logging, formation testing, core acquisition and fluid sampling. In addition, well integrity verification and Diagnostic Fracture Injection Testing (DFIT) of the petroleum wells at all well sites will be conducted.

Table 1 provides an overview of the key components of the regulated activity previously approved within EP161, and proposed new activities under the revised McArthur Basin Drilling Program EMP (STO2-7).

Table 1: Key components of previously approved EMPs for activities within EP161 and the revised McArthur Basin Drilling EMP

Component	Previously Approved Activities in EP161	Proposed New Activities in EP161
Drilling	<p>McArthur Basin Drilling Program EMP (approved 2019):</p> <ul style="list-style-type: none"> • drilling of Inacumba-1 pilot well and the Inacumba-1H horizontal well from the Inacumba-1 pilot • drilling of the Tanumbirini-2H horizontal well* • plugging and decommissioning of the deepest section of the Inacumba-1 pilot well* • DFIT of Tanumbirini-1 (drilled in 2014)* • well integrity monitoring • evaluation of Inacumba-1/1H and Tanumbirini-2H (including mudlogging, wireline/LWD, DFIT, coring)* • suspension and/or plugging and decommissioning of Tanumbirini-2H and Inacumba-1/1H* • rehabilitation of the Tanumbirini-1, Tanumbirini-2H and Inacumba-1H wells* <p>*Previously approved activities not completed, to be commenced in 2021 (hence changes in activity timeframes as outlined below)</p>	<p>Revised McArthur Basin Drilling Program NT Exploration Permit (EP) 161 EMP:</p> <ul style="list-style-type: none"> • drilling of Tanumbirini-3H well • drilling of Inacumba-2H well • evaluation of Inacumba-2H and Tanumbirini-3H (including mudlogging, wireline/LWD, DFIT, coring) • suspension and/or plugging and decommissioning of Inacumba-2H and Tanumbirini-3H • rehabilitation of the Tanumbirini-3H and Inacumba-2H wells
Petroleum wells	<p>Inacumba-1 pilot well Inacumba-1H horizontal well Tanumbirini-2H</p>	<p>Tanumbirini-3H Inacumba-2H</p>
<p>Activities:</p> <ul style="list-style-type: none"> • Mobilisation and rig up of drilling equipment • Drilling and well evaluation • DFIT • Demobilisation of equipment • Well suspension and/or decommissioning • Rehabilitation post well suspension • Rehabilitation post well decommissioning • Rehabilitation monitoring 	<p>Duration (commencement):</p> <ul style="list-style-type: none"> • 4 weeks (May/June 2019) • 15-25 weeks (June/July 2019) • 4 weeks (June/July 2019) • 2-4 weeks (Nov/Dec 2019) • 4 weeks (as required) • 1-2 weeks (as required) • 2-4 weeks (within 12 months of decommissioning) • 2 weeks per monitoring event 	<p>Duration (commencement):</p> <ul style="list-style-type: none"> • 4 weeks (April 2021) • 36-52 weeks (May 2021) • 11 weeks (to be determined) • 2-4 weeks (October 2021) • 4 weeks (as required) • 1-2 weeks (as required) • 2-4 weeks (within 12 months of decommissioning) • 2 weeks per monitoring event
AAPA Authority Certificate	C2019/043	No change required, all scope, including horizontal drilling, is within the boundary of the Authority Certificate
Groundwater aquifers	Gum Ridge Formation GRF10280 (193.5 ML/year)	Inacumba Unit U10335 (195 ML/year)

Component	Previously Approved Activities in EP161	Proposed New Activities in EP161
Groundwater monitoring bores	NT Exploration Permit 161 Tanumbirini North Water Bore Monitoring Program EMP (approved 2018): <ul style="list-style-type: none"> • 1 groundwater bore NT EP 161 Water Bore Monitoring Program EMP (approved 2018): <ul style="list-style-type: none"> • 3 groundwater bores 	No change required
Estimated groundwater required (total ML)	12 (3000 L used to date)	40
Land clearing (ha)	McArthur Basin Civil and Seismic Program NT Exploration Permit (EP) 161: <ul style="list-style-type: none"> • Tanumbirini – 6.5 ha • Inacumba – 5.7 ha 	No change required
Workforce	~40 - 45 peak workforce	~35 - 65 peak workforce
Accommodation camps	1 temporary at Inacumba well site 1 temporary at Tanumbirini well site	No change required
Traffic - heavy vehicle movements (per week)	~21	No change required
Drilling muds/cuttings generated at each of Inacumba and Tanumbirini well sites (m ³)	500/well	No change required
Wastewater predicted for offsite disposal (m ³)	~200	~400 No flowback fluid or produced water will result from conduct of the regulated activity
Greenhouse gas emissions (tCO ₂ -e)	~3,000 (total)	~5,500 (total)

Key information and data required across the phases of the activity are outlined in previous advice¹ and remain relatively unchanged from the information and data provided for the previously approved McArthur Basin Drilling Program EMP and include:

- 1) Basis of well design: The well will be constructed, maintained and decommissioned so there are at least two verified well barriers between deep, saline bearing formations and potable aquifers and the surface. Aquifers will be isolated behind cemented concentric casing strings. Casing, tubing, downhole permanent barriers and wellhead components will be tested during installation to confirm the integrity of all barriers that bound each annulus. Casing will be pressure tested prior to drilling out for the next hole section. Casing setting depth will be selected to protect resources including aquifer systems. Water based drilling fluids are to be used to minimise the risk of environmental impacts while drilling.
- 2) Drilling: The wells will be drilled to proposed true vertical depths of approximately 3,500 mTVD and 3000 mTVD at Tanumbirini and Inacumba respectively, and an estimated maximum total depth of 6,000 metres Measured Depth (mMD). Figure 1 below illustrates proposed target intervals of exploration wells relative to the deepest aquifer.

¹ NT EPA Advice 19 July 2019 https://depws.nt.gov.au/__data/assets/pdf_file/0020/730181/nTEPA-advice-to-minister-santos-mcArthur-basin-drill-explore-ep161.pdf

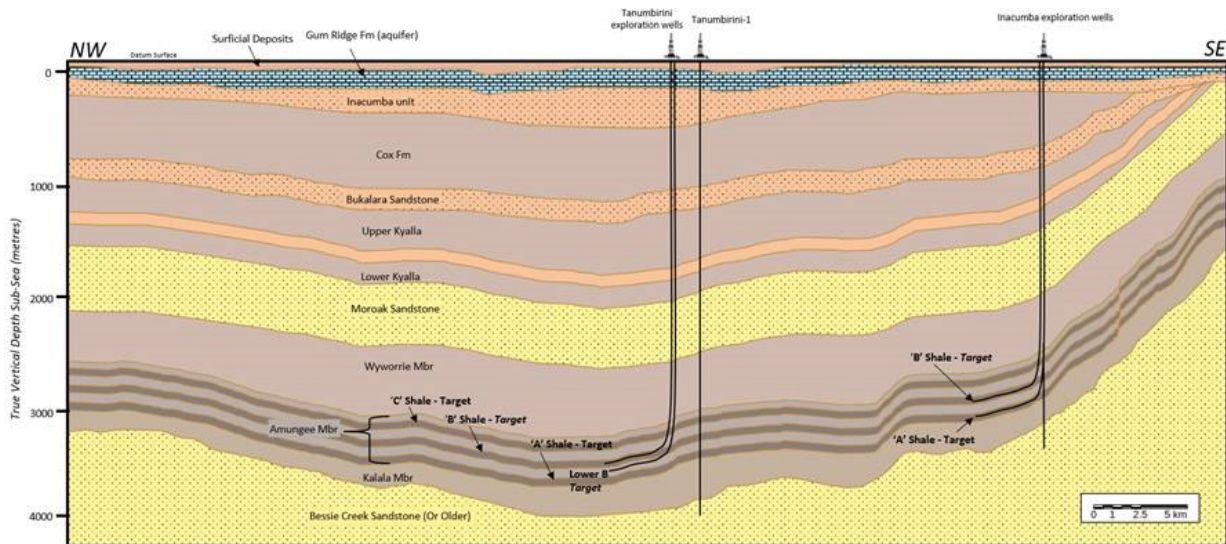


Figure 1: Illustrative section through the Beetaloo Sub-basin showing proposed target intervals of conceptual exploration wells relative to the deepest aquifer.

- a. At Inacumba, the horizontal well will be drilled towards the north-west or south-east from the vertical pilot hole, with the preferred direction to the north-west and geosteered using real-time Logging While Drilling (LWD) tools to remain in the optimum target zone defined by the Inacumba-1 pilot well. The horizontal wells are conceptually planned to reach a total depth of approximately 5,400 mMD/3,000 mTVD. At Inacumba, a minimum offset of approximately 2,000 m is expected between the base of the deepest aquifer and the top of the shallowest primary target of the horizontal section of the well, significantly exceeding the minimum offset, of more than 600 m between top target zone and base aquifer as mandated by the Code.
 - b. At Tanumbirini, the existing Tanumbirini-1 well, located approximately 50 m to the northeast of the new horizontal well Tanumbirini-3H, provides offset control, with the log data used as control for trajectory planning. The proposed horizontal well will be geosteered to remain in the optimum zone of the selected A, B, Lower B or C Shale intervals using real-time LWD tools. The horizontal wells are currently planned to reach a total depth of 5,900 mMD/3,500 mTVD. The top of this unit is expected to be intersected at approximately 3,400 mTVD. The deepest aquifer expected at this location is the Gum Ridge Formation. The base of this unit is expected to be intersected at approximately 200 mTVD. At Tanumbirini, a minimum offset of approximately 3,000 m is expected between the base of the deepest aquifer and the top of the primary target of the horizontal section of the well. This significantly exceeds the minimum offset, of more than 600 m, between top target zone and base aquifer as mandated by the Code.
 - c. Horizontal wells are not expected to exceed 3,000 m.
- 3) Geological hazard assessment: A geohazard assessment has been performed and the results of this assessment indicate that subsurface hazards such as abnormal pressure zones, shallow gas, lost circulation, major faults and potential zones of instability are unlikely to be encountered. The seismic sections have been reviewed and no major geohazards or faults have been identified at the proposed locations.
 - 4) Open hole evaluation, logging and testing: Well evaluation activities include mudlogging, LWD, wireline logging, formation testing, core acquisition, fluid sampling, open hole formation integrity testing (i.e. leak-off tests, formation integrity tests, or diagnostic fracture injectivity tests) and other standard oilfield evaluation techniques as deemed appropriate. Drill core and/or cutting samples will be collected for geological assessment and analysis and wireline logs will be acquired over the open hole section.

- 5) Diagnostic Fracture Injection Testing (DFIT): A DFIT refers to the act of injecting small volumes of a water (approximately 5-10 m³ per DFIT) to create a small fracture in the target interval. The well is shut-in and the pressure allowed to fall-off naturally. Monitoring the fall-off pressure over time allows information to be derived about the reservoir. The fluid does not contain proppant so that the fracture can relax and close naturally when pressure is released. The pressure changes are measured with high-accuracy gauges to calibrate the pre-DFIT mechanical earth model (MEM) and estimate formation characteristics such as breakdown pressure, fracture gradient, stress state and, potentially, permeability. The DFITs will provide information on fracture growth, fracture closure and permeability of the target formation(s), which are critical elements of a hydraulic fracture program design. Prior to the DFITs, a cement bond log will be run to determine the quantity and quality of the cement behind the production casing string. This will be followed by a pressure test to simulate the maximum pressure exerted on the casing string and wellhead during the DFIT. The above tests will confirm well bore integrity and zonal isolation between reservoir targets and aquifers. Following successful pressure testing and cement evaluation, the casing will be perforated using wireline perforating guns to provide communication between the well bore and the DFIT target.
- 6) Well suspension and decommissioning: After well evaluation, wells will either be suspended with cemented production casing and a 15 kpsi well-head for future re-entry, or decommissioned with permanent cement plugs installed in the well as per regulatory requirements.

1.1 Activity scope and duration

The revised EMP clearly describes the scope of the activity and its duration. The duration of the regulated activities is expected to be approximately 18 months (indicative), subject to approval of the regulated activity and seasonal access. On completion of exploration well drilling and technical evaluation the exploration well will either be suspended for future re-entry, or in a non-success case, a decision made to decommission the exploration well with permanent cement plugs in accordance with the Code.

Drilling will be conducted using an overbalanced water-based mud system, planned to provide primary well control. This method of drilling entails maintaining a higher pressure in the petroleum well bore than in the surrounding formation, and is achieved by using a weighted drilling mud system. The resulting pressure gradient between the mud filled well bore and the formation prevents influx of formation fluids into the well bore. Drilling fluids are free from benzene, toluene, ethylbenzene and xylene, and all proposed and contingency chemicals have been assessed to determine whether they could be considered to be, or to contain, hazardous substances. It is expected that approximately 500 m³ of drill cuttings will be produced for each well, which will be contained in lined sumps, in accordance with the Code. Sumps will be managed to maintain a minimum freeboard of 300 mm in the dry season and 1500 mm in the wet season, to accommodate a 1 in 1000 average recurrence interval (ARI) rainfall rate. Drilling fluids will initially be reused, and after evaporation, any remaining fluids will be disposed of offsite prior to the onset of the wet season. Residual solid waste (from evaporated drill fluids) will be mixed in with drill cuttings, and subject to an assessment of suitability, will either be buried and disposed of in-situ, or removed for disposal in a licenced facility.

Groundwater extraction may occur from established bores in the Gum Ridge Formation and the Inacumba Unit, with an estimated total requirement of 40 ML. The Gum Ridge Formation extraction licence (GRF10280) allows 193.5 ML/year, representing 22.7% of the total of all licences accessing this formation. The Inacumba Unit extraction licence (U10335) allows 195 ML/year and the interest holder is the only water licence accessing this formation.

Information on the location and scale of the proposal is provided in the revised EMP. The existing environment has been adequately described through previous baseline surveys and is sufficiently understood. The well sites are adjacent to ephemeral drainage lines, which support riparian vegetation and the revised EMP adequately provides mitigation measures to prevent degradation of this sensitive vegetation type and to prevent contamination of surface waters during periods of flow. Three of the identified threatened species and one listed migratory species with potential to occur in

the immediate vicinity of the well sites are considered to have a medium likelihood of occurrence. The revised EMP includes mitigation measures to minimise potential for impact to these species. The impact and risk assessment is based on information gathered during environmental baseline surveys and experience drilling Tanumbirini-1 and undertaking civil and seismic activities within EP161. The potential impacts and risks of the regulated activity have been identified and relevant environmental outcomes, performance standards and measurement criteria have been provided in the revised EMP. Mitigations outlined in the risk register are classified based on the hierarchy of controls and the level of certainty is indicated for each risk.

1.2 General compliance with Code

The revised EMP demonstrates how the interest holder will comply with relevant requirements of the Code in undertaking this regulated activity. This includes selection of materials for use in well construction and related engineering controls contained in the Well Operations Management Plan (WOMP) to be accepted by the Department of Industry, Tourism and Trade (DITT) prior to the commencement of drilling. The risk assessment provided in section 6 of the revised EMP cross references relevant sections of the Code that apply to the mitigation and management measures to enable the reviewer to identify and confirm that the proposed regulated activity complies with the Code. The revised EMP also provides the following plans, which are compliant with the Code:

- Wastewater Management Plan
- Spill Management Plan, including an assessment of the hazardous nature of all chemicals proposed to be used, a spill risk assessment and response strategy
- Emergency Response Plan
- Weed Management Plan
- Fire Management Plan.

Erosion and sediment control and rehabilitation of all ground disturbance are managed under the approved Civils and Seismic EMP. Rehabilitation in the revised EMP is limited to removal of surface infrastructure.

Groundwater monitoring has already commenced at impact and control monitoring bores under previously approved EMPs, and is available from the DEPWS website. Groundwater will continue to be monitored on a quarterly basis and analysed at a NATA accredited laboratory for an array of analytes. As required in the Code and the *Preliminary Guideline: Groundwater Monitoring Bores for Exploration Petroleum Wells in the Beetaloo Sub-basin*, the interest holder must undertake ongoing groundwater monitoring for three years from the approval date of the EMP, to demonstrate 'no change' to groundwater quality or quantity. This monitoring commenced under the previously approved drilling EMP and will continue. Other environmental monitoring and inspections include a baseline soil survey, annual weed and fire fuel load surveys, drilling fluid and cuttings characterisation, daily monitoring of predicted weather, daily monitoring of fire conditions and daily inspections of drill fluid levels, pits, dams and fences. Continuous X-ray fluorescence (XRF), including naturally occurring radioactive materials, will be undertaken during drilling to characterise the composition of the drill cuttings to verify that cuttings do not pose a safety or environment hazard.

The level of detail and quality of information provided in the revised EMP is sufficient to inform the evaluation, assessment and management of potential environmental impacts and risks, and meets the EMP approval criteria under Regulation 9(1)(b). As a further precautionary step, the NT EPA has provided advice relating to Ministerial Conditions for this EMP contained at the end of this advice.

2. Principles of ecologically sustainable development (regulation 2(a))

2.1 Decision making principle (s 18 *Environment Protection Act 2019* (NT))

The revised EMP adequately assesses the environmental impacts and risks associated with the regulated activity and outlines appropriate avoidance and mitigation measures. The regulated activity will increase activity intensity at each of the Inacumba and Tanumbirini well sites, while constraining the exploration to these locations. In this context, use of the existing well sites to establish multiple wells at each location, minimises the footprint of potential and actual environmental impacts. The outcomes of this regulated activity will continue to inform decision-making about longer-term petroleum activities in the McArthur Basin, in which lies the Beetaloo Sub-basin.

The impacts and risks associated with the drilling program have been assessed in the EMP. Of the 29 risks identified, 23 are assessed as “negligible” if carried out in accordance with the mitigations and controls proposed in the revised EMP. These controls have been assessed by NT Government agencies and deemed adequate.

The drilling sump design has a total useable capacity increased to 5,535 m³ (excluding the freeboard) which complies with the Code to conservatively accommodate a 1:1,000 year rainfall occurrence during the wet season. A wet season freeboard of 1,500 mm is applied to all waste storage infrastructure which increases the total drilling sump capacity to 10,935 m³.

The interest holder has demonstrated ongoing stakeholder engagement in the revised EMP, as required by the Regulations, with identified, directly-affected stakeholders. The revised EMP was also made available for public comments (25 November 2020 to 23 December 2020).

2.2 Precautionary principle (s 19 *Environment Protection Act 2019* (NT))

The NT EPA considers there is a low threat of serious or irreversible damage from the regulated activity. The interest holder’s investigations into the physical, biological and cultural environment provide a satisfactory scientific basis to assess potential environmental impacts and risks, and to identify measures to avoid or minimise those impacts and risks and address scientific uncertainty.

The risk assessment clearly demonstrates consideration of risk events in the context of the environment in which the regulated activity is conducted and its particular values and sensitivities, and the spatial extent and duration of the potential impact. Uncertainty in relation to the environmental features was assessed, with no areas of environmental uncertainty identified. The revised EMP outlines the interest holder’s investigations into the physical, biological and cultural environment and demonstrates a sound understanding of the environment at the location, providing a satisfactory scientific basis to assess potential environmental impacts and risks for the activity, and to identify measures to avoid or minimise those impacts and risks.

The risks of drilling over the wet season, should it be required, are well understood and described. The revised EMP demonstrates adherence to the Code that establishes best practice management measures for operations, as set out in the risk assessment and Wastewater Management and Spill Management Plans. The revised EMP includes the assessment of impacts and risks for wet season operations and management strategies, including measures such as daily monitoring of open drill rig mud tanks during drilling operations, use of sensors and inspections to ensure safe operating fluid levels are maintained, avoidance of transportation of wastewater or chemicals on unsealed roads without a prior risk assessment, maintenance of sufficient fuel and chemicals on site to allow for continuous operations, and use of helicopters to transport personnel when access is restricted. The interest holder also receives a detailed 8-day weather forecast which is reviewed daily.

There are internationally recognised standards and established management measures in well design, operation and well integrity monitoring to ensure aquifer protection; these are reflected in the mandatory requirements of the Code. The surface separation distance (10 m) is calculated from the hole centre to hole centre and is selected to accommodate the rig package and future well interventions. Sub-surface separation distances are estimated to be 500 m based on targeting

separate shale intervals. Drilling will be geosteered using real-time logging while drilling (LWD) tools to remain in the optimum target zone.

The NT EPA is of the view that the precautionary principle has been considered in assessing the regulated activity and has not been triggered due to the low threat of serious or irreversible damage occurring and the presence of a satisfactory scientific basis to assess potential impacts and risks. In addition, the existing environmental monitoring commitments contained in the EMP are compliant with the Code and provide measureable performance measures to ensure that the environmental outcomes are met.

2.3 Principle of evidence-based decision-making (s 20 *Environment Protection Act 2019* (NT))

The revised EMP demonstrates an adequate understanding of the environment in which the regulated activity will be undertaken, and considers all relevant aspects of the environment that have potential to be affected. As the EMP proposes to establish multiple wells at each well pad, it includes a consideration of potential environmental impacts and risks associated with increased storage requirements for chemicals and wastewater, includes mitigations for ensuring horizontal wells do not interact, and includes a geohazard assessment.

The revised EMP commits to storing sufficient volumes of chemicals on site during the wet season to enable drilling to continue into the wet season if required. Transport, handling, storage and use of chemicals is to be undertaken in accordance with the Code. The EMP includes a risk assessment related to transport of chemicals to site during the wet season, which concludes there is a low risk of environmental harm with implementation of the proposed management measures.

The information in the revised EMP indicates there are no potentially exposure pathways from drilling chemicals to impact potable groundwater sources in proximity to the regulated activity. Environmental mitigation controls include:

- physical vertical separation distances between the aquifer and target formation to prevent any migration of drilling fluid to aquifers (> 2,000 m)
- approximately 1.5 km horizontal separation distance between the exploration well and the closest existing water supply bore used for domestic or stock consumption at Tanumbirini, and approximately 3 km horizontal separation distance at Inacumba
- storage of hazardous chemicals or those that may cause environmental harm within secondary containment with sufficient capacity to hold 110% of the largest stored container or within tanks equipped with safety features such as double-skin, spill kits available at all potential spill areas and a comprehensive spill management plan
- use of conservative wet and dry season freeboard for drill cuttings sumps.

The revised EMP aligns with the requirements of the Code, including tracking of water use and wastewater generation and movement.

The NT EPA has assessed the potential for spills from chemicals and hydrocarbons (e.g. diesel) stored in designated bunded areas at each location and concluded that the proposed management measures are satisfactory. The mitigations described in the EMP include existing bunding around chemical storage areas, containment of hydrocarbons in double-lined diesel storage tanks and spill prevention and response procedures for hazardous spill prevention, monitoring, assessment, response and clean-up. Nonetheless, the NT EPA has recommended the interest holder provide DEPWS with a written report of any contaminant incidents exceeding 200 litres, within 24 hours of the incident being detected.

The proposed environmental outcomes are likely to be achieved based on the best available information on the nature and scale of the activity, and the environment in which the regulated activity will be conducted. The studies previously undertaken by the interest holder to inform the EMP affords the interest holder with a detailed and reliable knowledge of the potential environmental impacts and risks and the most appropriate measures for mitigation of those impacts and risks.

The NT EPA is of the view that the evidence-based decision-making principle has been considered in assessing the regulated activity and that in the circumstances, decisions can be based on best available evidence that is relevant and reliable.

2.4 Principle of intergenerational and intra-generational equity (s 21 *Environment Protection Act 2019* (NT))

The potential environmental impacts and risks associated with the regulated activity can be adequately avoided or managed through the management measures and ongoing monitoring programs proposed in the EMP.

Protection of cultural interests is achieved through compliance with the requirements of Authority Certificates issued by the Aboriginal Areas Protection Authority under the *Northern Territory Aboriginal Sacred Sites Act 1989* (NT) and the previously completed archaeological assessment at the site to avoid archaeological heritage impacts. The regulated activity is subject to requirements of the AAPA Certificate C2019/043.

The proactive measures included in the revised EMP regarding bushfire and weed management (such as fuel monitoring and weed surveys and control) will have an overall positive impact on the condition of the environment for future generations. In addition, the revised EMP and previously approved EMPs relating to EP161 commit the interest holder to progressive rehabilitation throughout the life of the activity which, combined with the Code requirements, is considered to reduce the risks to biodiversity and soil contamination to ALARP and acceptable levels.

Greenhouse gas emissions generated by the regulated activity in the revised EMP are not considered significant when considering the regulated activity will result in an overall increase in NT GHG emissions of approximately 0.007%, based on fuel combustion and fugitive emissions. The revised EMP also includes an assessment of the cumulative greenhouse gas emissions from the regulated activity and the interest holder's previously approved regulated activities, which total approximately 17,000 tCO₂-e. This represents an approximate increase of 0.02% overall in annual Northern Territory emissions reported for 2018-19.

The NT EPA considers that environmental values will be protected in the short and long term from the activities outlined in the EMP and that the health, diversity and productivity of the environment will be maintained for the benefit of future generations.

2.5 Principle of sustainable use (s 22 *Environment Protection Act 2019* (NT))

Exploration is necessary to enable commercial appraisal of resources. In the absence of reliable data regarding the shale resource, exploration will take a number of years to complete, in order to assess the viability of the resource prior to production.

Cumulative impacts of groundwater extraction have been assessed. The interest holder has groundwater extraction licences GRF10280 and U10335, with a maximum water entitlement of 193.5 ML/year from the Gum Ridge Formation and 193.5 ML/year from the Inacumba Unit. The anticipated water demand for this regulated activity is 40 ML, which is much less than the interest holder's maximum water entitlement. Activities conducted to date under the approved drilling EMP have used approximately 3,000 L. Annual cumulative groundwater extraction from the Gum Ridge Formation from all licenced bores (approximately 850 ML) is currently well below the storage ranges of 1,766,000 to 3,532,000 GL. Currently there are no other extraction licenses for the Inacumba Unit, which is estimated to be a 300 GL resource.

A conservative estimate of total greenhouse gas emissions likely to be generated by the regulated activity is approximately 5,500 tCO₂-e. The NT EPA notes that the Government has committed to implementing all recommendations of the Hydraulic Fracturing Inquiry, including that the NT Government seeks to ensure there is no net increase in the lifecycle GHG emissions emitted in Australia from any onshore petroleum produced in the NT. To support the NT Government's commitment, the NT EPA has provided advice that the interest holder provide to DEPWS annual

actual scope 1 and scope 2 greenhouse gas emissions reported under the National Greenhouse Energy Reporting Scheme (NGERS) versus predicted emissions in the EMP.

The NT EPA is of the view that the sustainable use principle has been considered in assessing the regulated activity.

2.6 Principle of conservation of biological diversity and ecological integrity (s 23 Environment Protection Act 2019 (NT))

Site selection for establishment of well pads under the previously approved Civils and Seismic EMP was informed by a detailed ecological assessment, which covered a much larger area than that required to be cleared of vegetation, thereby enabling the interest holder to establish larger lease pads to support a multi-well configuration and minimise impacts from additional land clearing.

The location of the regulated activity is not within close proximity to groundwater dependent ecosystems; nor is it within proximity to a declared ecological community under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

The regulated activity is located at the junction of the Gulf Fall and Upland bioregion and the Sturt Plateau bioregion and poses a low risk to the ecosystems within these bioregions, given the relatively small area footprint of the regulated activity and the very large area of similar habitat. The regulated activity does not pose a significant risk to any regional populations of threatened species. Three of the identified threatened species and one listed migratory species with potential to occur in the immediate vicinity of the well sites are considered to have a medium likelihood of occurrence. Due to the management strategies outlined in the EMP and the relatively small area of impact, it is unlikely that the regulated activity will pose a risk to the identified threatened species. Impacts and risks to flora, fauna, and ecosystems have been mitigated to an acceptable level.

The DEPWS Flora and Fauna Division is satisfied the proposed activities do not pose a significant risk to threatened species or significant habitats and vegetation types. Further, avoidance and mitigation measures identified in the EMP are adequate to reduce risks from, for example, vehicle-strike, dust, erosion and/or spills to as low as reasonably practicable, in relation to potential impacts on biodiversity.

The Tanumbirini well pad is near to a second order intermittent stream which drains to Tanumbirini Creek, and ultimately to the Cox River. The Inacumba well pad is located near to the Inacumba Creek, which ultimately drains to the Limmen Bight River. Flood modelling indicates the lease pad at the Tanumbirini location, which was established in 2014, will be subject to flooding of an average depth of 1 to 1.5 m during a 1 in 100 AEP flood event, but the supporting infrastructure areas, including the camp, tank pads and laydown areas in the south east would remain unaffected. The Inacumba location including the lease pad and the supporting infrastructure areas remains mostly unaffected in a 1 in 100 AEP flood event. Potential offsite impacts to the tributaries of the Cox River and the Limmen Bight River have been adequately addressed by the mitigation and management measures provided in the Wastewater Management Plan and Spill Management Plan that were developed in accordance with the Code.

The EMP outlines measures to minimise impacts on affected environmental values, including the management of threatening processes such as weeds and fire. Where relevant, management measures for the aforementioned threatening process are consistent with the requirements of the Code, the *NT Land Clearing Guidelines* and the *Weed Management Planning Guideline: Onshore Petroleum Projects*. Specific precautions to ensure interaction with wildlife is avoided are included in the EMP, including installation of fencing around sumps, installation of fauna ladders/escapes and daily checks of all sumps, appropriate storage of waste and use of speed limits on access roads.

The NT EPA considers that implementation of, and compliance with, the EMP will ensure the conservation of biological diversity and ecological integrity is not impacted by the regulated activity.

2.7 Principle of improved valuation, pricing and incentive mechanisms (s 24 Environment Protection Act 2019 (NT))

The interest holder is required to prevent, manage, mitigate and make good any contamination or pollution arising from the regulated activity, including contamination of soils, groundwater and surface waters through accidental spills.

All stages of the regulated activity, including disposal of waste, commercial purchase of groundwater, and progressive rehabilitation of all disturbed areas to an acceptable standard, are at the cost of the interest holder. The interest holder is required to provide an adequate environmental rehabilitation security bond to indemnify the NT Government. This is based on an assessment by DEPWS of the estimated rehabilitation cost submitted by the interest holder.

The NT EPA is of the view the principle of improved valuation, pricing and incentive mechanisms has been considered in assessing the regulated activity and is based on the interest holder bearing any environmental costs for the activity.

3. Environmental impacts and risks reduced to a level that is as low as reasonably practicable (ALARP) and acceptable (regulation 9(1)(c))

The interest holder has committed to identified measures to avoid impacts on environmental values, informed by a baseline studies, surveys and data derived from seismic data and drilling of Tanumbirini-1.

The revised EMP demonstrates a systematic identification and assessment of environmental impacts and risks associated with the regulated activity. The key new potential environmental impacts and risks considered in the revised EMP are:

- increased volumes of drill cuttings and associated wastewater
- conduct of the regulated activity in the wet season, should it be needed, to consider transport of chemicals and wastewater on unsealed roads in the wet season
- operation of a multi-well well pad
- potential for interplay between horizontal wells.

The revised EMP also considers cumulative impacts to groundwater and greenhouse gases and concludes the cumulative impacts are not significant.

The EMP has provided demonstration of why the controls to be implemented are considered ALARP and acceptable. Of the 29 environmental risks identified by the interest holder, 23 are considered 'negligible' risk, and therefore are ALARP and acceptable. The remaining six risks are considered 'acceptable' as long as the risk is ALARP and acceptable and the interest holder has included mitigations that can/will be implemented such that the risks will therefore be managed at levels that are ALARP. Specifically:

1. *Loss of native vegetation through introduction of weeds and resultant competition for resources:* The interest holder has prepared a Weed Management Plan (Appendix E), which has been deemed adequate to mitigate this risk. The 'acceptable' risk ranking is based on the likelihood being considered 'unlikely', but the consequence of the event occurring being considered to potentially having up to extensive impacts to the environment and remediation being difficult.
2. *Localised contamination of soil from leaks and spills:* The interest holder has identified the potential for chemical leaks and spills associated with chemical and fuel storage and handling to potentially impact on soil quality. The interest holder has complied with requirements of the Code to minimise the potential for soil contamination to occur, including a commitment to remediate any contaminated soil. The 'acceptable' risk ranking is based on the likelihood being considered 'unlikely', but the consequence of the event occurring being considered to potentially having up to extensive impacts to the environment and remediation being difficult.
3. *Reduction in surface and groundwater quality from leaks and spills:* The interest holder has identified the potential for chemical leaks and spills associated with chemical and fuel storage

and handling to potentially impact on surface water and groundwater quality. The interest holder has complied with requirements of the Code to minimise the potential for contamination of surface water and groundwater, including additional mitigations to prevent overland flow of stormwater entering drill cuttings sumps during a 1 in 100 year rainfall event. The Spill Management Plan (Appendix H) is comprehensive and includes appropriate measures for preventing and responding to spills and leaks. The 'acceptable' risk ranking is based on the likelihood being considered 'unlikely', but the consequence of the event occurring being considered to potentially having up to extensive impacts to the environment and remediation being difficult.

4. *Reduction in groundwater quality from cross-flow between aquifers and petroleum:* The interest holder has identified the potential for groundwater quality to be reduced during drilling, construction, operation and decommissioning activities, as well as from having multiple wells on a single well pad. In addition, the interest holder has considered well blow-outs, and the presence of faults or major structures enabling cross-flow. The interest holder has committed to comply with the requirements of the Code and a WOMP accepted by DITT to ensure well integrity is maintained at all stages of the regulated activity. The revised EMP includes a geohazard assessment, which concluded that subsurface hazards such as abnormal pressure zones, shallow gas, lost circulation and potential zones of instability are unlikely to be encountered, and seismic data indicates no major faults present in the vicinity of the regulated activity. The interest holder has been conducting groundwater monitoring from control and impact bores since approval of the drilling EMP in 2019, and will continue under this revised EMP. Potential for interplay between wells has been considered and based on the methods proposed for drilling (including LWD) is considered to be unlikely to occur. The 'acceptable' risk ranking is based on the likelihood being considered 'unlikely', but the consequence of the event occurring being considered to potentially having up to extensive impacts to the environment and remediation being difficult.
5. *Reduction in inland surface water quality from overflow of pits and leaching:* The interest holder has identified the potential for impacts to surface water quality resulting from loss of containment or leaching from pits. The interest holder has conducted flood modelling which indicates the potential for minor flooding to occur on some parts of the Tanumbirini well pad in a 1 in 10 year rainfall event, and more extensive flooding in a 1 in 100 year rainfall event. Accordingly, the interest holder has committed to removing residual drill fluids from the well pads prior to the commencement of the wet season, and have designed the drill cuttings sumps to over four times the capacity actual required for the amount of cuttings to be produced, with an additional 0.3 m bund on the outside wall of the sumps. Further, a conservative freeboard of 1,500 mm in the wet season has been adopted (compared to a calculated requirement of 1,168 mm). The 'acceptable' risk ranking is based on the likelihood being considered 'unlikely', but the consequence of the event occurring being considered to potentially having up to extensive impacts to the environment and remediation being difficult.
6. *Reduction in soil quality from overflow of pits and leaching:* The interest holder has identified the potential for impacts to soil quality resulting from loss of containment or leaching from pits. The same mitigation measures listed for risk 5 above are applied to minimise the risk of contamination to ALARP and acceptable levels. The 'acceptable' risk ranking is based on the likelihood being considered 'unlikely', but the consequence of the event occurring being considered to potentially having up to extensive impacts to the environment and remediation being difficult.

The NT EPA considers that all reasonably practicable measures will be used to control the environmental impacts and risks, considering the level of consequence and the resources needed to mitigate them, and the nature, scale and location of the regulated activity. The NT EPA considers that the environmental impacts and risks will be reduced to a level that is ALARP and acceptable, considering the sensitivity of the local environment, relevant standards and compliance with the Code. As a further precaution, the NT EPA recommends that the interest holder should provide to DEPWS a contingency strategy to be implemented in the event that weather forecasting indicates significant flooding at the well sites is likely, such that drill cuttings can be safely managed to prevent impact to the environment from overland flooding.

4. Summary of monitoring and inspections

Table 2 provides a summary of the monitoring and inspections committed to in the EMP. These programs are used by the interest holder to meet prescribed requirements and to confirm the effectiveness of the mitigations committed to.

Table 2: Monitoring and inspections relevant to the scope of the regulated activity

Aspect	Monitoring and inspections
Weeds	<ul style="list-style-type: none"> • Annual post-wet season monitoring of lease pads and access tracks • Annual monitoring of fuel loads post-wet season • Periodic audit of hygiene declarations available for all vehicles coming into EP161 on each occasion
Bushfire	<ul style="list-style-type: none"> • Daily assessment of bushfire weather alerts during operations • Annual fire mapping • Weekly inspection of fire suppression equipment at chemical stores and in vehicles
Rehabilitation	<ul style="list-style-type: none"> • Establishment of photo-points • Repeat after well completion (remaining scope is in the approved Civils and Seismic EMP)
Water and Wastewater	<ul style="list-style-type: none"> • Daily checks of pits and sumps during drilling, including during and after rainfall events, to confirm available freeboard • Periodic audits to ensure only waste from approved wastewater systems and grey water is disposed of to land • Ongoing during conduct of the regulated activity (as applicable to the scope), tracking of volumes of water to be used and reused during drilling, volumes of water used for dust suppression and construction, volumes of water and wastewater removed for off-site disposal and end-destination, and volumes of any spills of water or wastewater
Groundwater	<ul style="list-style-type: none"> • Ongoing monitoring of groundwater quality from control groundwater bores (including 6 months prior to drilling and including wet and dry season conditions) • Ongoing monitoring of groundwater extraction • Daily monitoring of stored water volumes during operations
Soils	<ul style="list-style-type: none"> • Baseline assessment of physical properties of soils at each well site
Greenhouse gas emissions	<ul style="list-style-type: none"> • Real time monitoring during drilling of gas detection
Fauna	<ul style="list-style-type: none"> • Daily inspection during operations of fences, excavations, pits and sumps for entrapped fauna and fauna and to ensure fauna escapes are intact • Daily inspection of waste storage areas to ensure no fauna access • Periodic audits to ensure lighting directed inwards at well pads to minimise potential fauna impacts
Drill fluids, drilling muds and chemicals	<ul style="list-style-type: none"> • Daily monitoring of fluid levels in drilling fluid tanks • Monthly analysis of drill fluids for characterisation purposes during drilling • Analysis of drill cuttings analysis at end of drilling operations • Weekly inspection of chemical storage areas
Weather	<ul style="list-style-type: none"> • Daily monitoring of weather during operations for predicted significant rainfall
Vehicles and equipment	<ul style="list-style-type: none"> • Ongoing use of in-vehicle monitoring systems to ensure compliance with speed restrictions and no unauthorised travel outside of designated areas • Ongoing use of equipment maintenance logs to demonstrate engines and machinery have been maintained in accordance with required maintenance schedule and have been fitted with noise suppression devices • Periodic audits to show no use of petrol vehicles and petrol-powered pumps have spark arrestors fitted
Dust	<ul style="list-style-type: none"> • Maintenance of records of use of water cart for dust suppression and locations (linked to weather observations)

5. Relevant matters raised through public submissions

Public consultation on the EMP was required under regulation 8A. The revised EMP was advertised for public comment in the NT News and Katherine Times and made available for public comment for 28 days from 25 November to 23 December 2020. A total of 172 submissions were received, of which 169 were form letters from two public campaigns. Eighty-two submissions (47.4%) were identified as originating within the NT, noting 30 submissions (17.3%) did not identify their origin. Table 3 summarises the issues raised. In summary, all submissions were opposed to onshore petroleum development and raised substantially similar issues as those addressed through the *Scientific Inquiry into Hydraulic Fracturing of Onshore Unconventional Reservoirs in the Northern Territory* (HFI) and subsequent implementation of the 135 HFI recommendations.

Table 3: Consideration of relevant matters raised in public submissions

Theme	Overview of issues raised
Flora and fauna (environment)	<ul style="list-style-type: none"> • impact on birdlife from use of open dams • impact on ecosystems and wildlife from habitat fragmentation • impact to one threatened ecological community, 15 threatened species and two species that are both threatened and migratory
Social and cultural	<ul style="list-style-type: none"> • concerns as to the extent of stakeholder engagement • impact on the NT economy and lack of economic gains from the onshore petroleum industry • damage to cultural heritage sites • wet season transport and consequence of an accident
Climate change	<ul style="list-style-type: none"> • greenhouse gas emissions • use of NGRS emissions estimates rather than measurements
Water	<ul style="list-style-type: none"> • impact of spilt contaminants on ecologically important temporary or permanent waterbodies • downstream impacts to the Towns River, Magaranyi River, Cox River, Mantungula Creek, Lagoon Creek, Tanumbirini Creek, October Creek and Limmen Bight River from transport of chemicals and waste • impacts to water security • contamination of groundwater via sulfide corrosion impacting well integrity • impacts to the Moroak Sandstone aquifer • hydraulic fracturing in the wet season
Waste	<ul style="list-style-type: none"> • wet season overtopping of wastewater storage ponds
Human Health	<ul style="list-style-type: none"> • impact on human health and safety • public disclosure of Chemical Abstracts Service (CAS) numbers of chemicals and oil and gas wells in which they are used • recommendation to NT government to require that manufacturers conduct health testing before chemicals can be manufactured • ban use of chemicals that pose risks to aquatic life
Regulation and compliance	<ul style="list-style-type: none"> • fragmented approvals • lack of transparency and scientific scrutiny • cumulative impacts • consideration of direct and indirect impacts • referral under the <i>Environment Protection Act 2019</i> (NT) (EP Act) and the <i>Environment Protection and Biodiversity Conservation Act 1999</i> (Cth) (EPBC Act)

1. **Flora and fauna:** Submissions raised concerns about the risk to birds from open drill cuttings sumps, habitat fragmentation and impacts to threatened ecological communities, threatened species and a migratory species. The EMP appropriately identifies the risks and potential impacts in relation to interactions between the regulated activity and fauna and flora, including an assessment of listed species and threatened ecological communities within a 10 km radius of the location of the regulated activity. The assessment of risk from the regulated activity was based on both field-based and desktop assessments, giving a high level of data certainty. While it is noted that concerns have been raised about the potential for threatened species, such as the Bilby, or groundwater dependent ecosystems, such as springs, to be impacted, the regulated activity is confined to a small footprint, which is not in proximity to previous Bilby sightings or suspected groundwater dependent ecosystems. Further, temporary effects of habitat fragmentation are ameliorated through the requirements of clause A.3.9 of the Code for rehabilitation such that the rehabilitated area is ecologically integrated with the surrounding landscape at the end of the regulated activity.

Specific submissions were made in regards to the potential for the 'vulnerable' Bilby (*Macrotis lagotis*) to occur in the location of the regulated activity. An analysis by the interest holder in response to the submission indicates this is unlikely to occur in proximity to the well sites, as indicated in Figure 2 below, and the revised EMP includes mitigations to prevent macrofauna access to the drilling sumps.

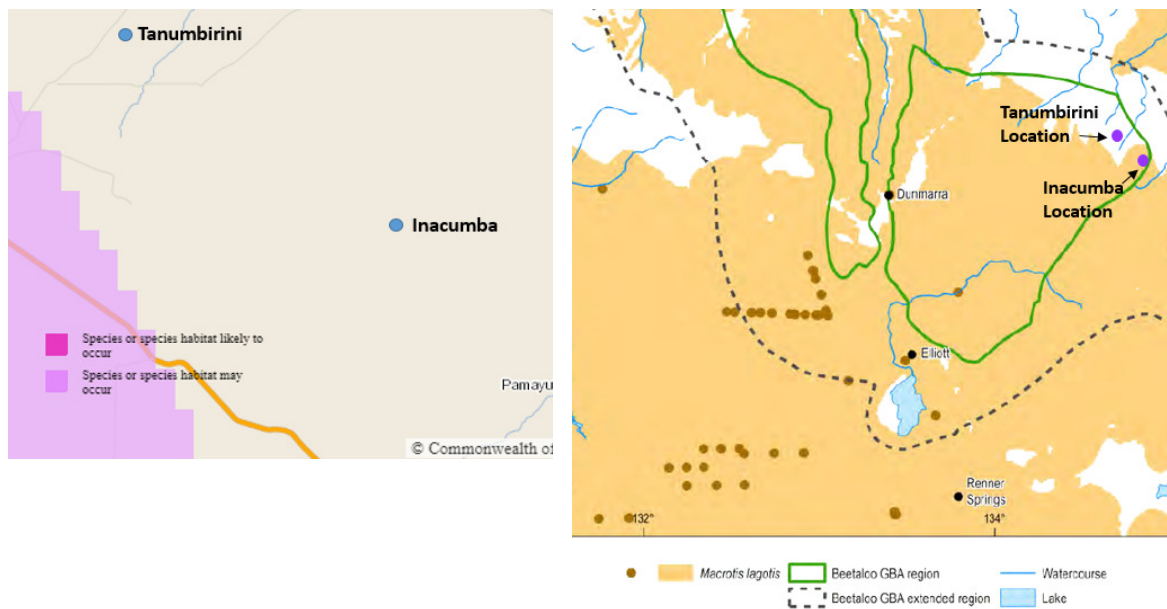


Figure 2: Assessment of available habitat for the Bilby (left) and known records (right), in relation to the location of the regulated activity

Indirect impacts to fauna and flora, such as through dust impacts on habitat areas and loss of containment of wastewater that could enter drainage lines, have been considered in the revised EMP, and it is concluded there is a low likelihood of occurrence with the controls proposed. Potential indirect impacts on fauna as a result of an increase in cane toad numbers is not specifically addressed in the EMP, however, management of pest species in general is a commitment in the revised EMP.

The NT government is currently working with independent experts, research agencies such as CSIRO, and industry to undertake a comprehensive Strategic Regional Environmental and Baseline Assessment (SREBA) in prospective onshore petroleum basins prior to granting any production approvals. These studies are expected to include potential impacts to stygofauna.

2. **Social and cultural:** Public submissions raised concerns about social aspects such as the adequacy of stakeholder engagement, impact of the onshore petroleum industry on the NT economy, specifically a lack of resultant economic gain, damage to cultural heritage sites and consequences of a wet season transport accident. The EMP includes a stakeholder engagement report, which makes clear that there are processes to ensure there is no risk or

impact to sacred sites and cultural heritage as a result of the regulated activity, and to date no objections have been raised with the interest holder by identified stakeholders. The interest holder has engaged with the Traditional Owners and the Northern Land Council and affected landholders as part of their stakeholder engagement, in accordance with the definition of a stakeholder, as defined in regulation 7(3) of the Regulations. Engagement with Traditional Owners is co-ordinated through the Northern Land Council and has been undertaken in accordance with:

- section 41(6) of the *Aboriginal Land Rights (Northern Territory) Act 1976* (Cth), when supplying information to Native Title holders for the purposes of negotiating an onshore gas exploration agreement
- regulation 7 of the Regulations, during the preparation of an EMP, which outlines the minimum requirements that an interest holder must meet when undertaking stakeholder engagement
- regulation 9 of the Regulations, during the preparation of an EMP, which requires the proponent to include an Authority Certificate in accordance with section 3 of the *Northern Territory Aboriginal Sacred Sites Act 1984* (NT).

The revised EMP includes a detailed archaeological assessment of the work area in Appendix F, which concludes no further archaeological survey is required, unless Aboriginal or non-Aboriginal sites/relics are uncovered during conduct of the regulated activity. As the regulated activity does not include any new ground disturbance and the revised EMP includes controls relating to education of the workforce on cultural heritage and not leaving the designated work area, it is highly unlikely that impacts to Sacred Sites or archaeological sites will occur.

The assessment of the revised EMP, its potential impacts (positive and negative) and the management measures used to enhance positive and reduce negative impacts takes into consideration the ESD principles. Interest holders are engaged in exploration activities necessary to enable commercial appraisal of resources. In the absence of reliable data regarding the shale resource, exploration will take a number of years to complete, in order to assess the viability of the resource prior to production. The HFI included economic modelling completed by ACIL Allen, which suggested there will be limited impact on sectors outside of any onshore petroleum industry and its supply chain. Additional revenue accruing to the NT Government over the 25-year modelled period under four development scenarios where gas production occurs is between \$757 million and \$3.72 billion.

The revised EMP considers the risks associated with transport of chemicals and wastewater during the wet season and the interest holder has committed to undertaking an assessment of road conditions prior to mobilisation on unsealed roads. This is supported by detailed daily weather monitoring and forecasting and a commitment to ensure transport of wastewater only uses enclosed tanks.

3. *Climate change*: Public submissions raised concern about greenhouse gas emissions and the method of estimated these emissions. The revised EMP provides predicted greenhouse gas emissions as being 5,500 tonnes of carbon dioxide equivalent (tCO₂-e) during conduct of the regulated activity. Overall, the total annual emissions from the drilling program represents approximately 0.007% of the total estimated annual GHG emissions for the NT for 2018 of 16 million tCO₂-e. The method used for calculation of emissions is consistent with the requirements of the Australian Clean Energy Regulator, and this is reflected in the mandatory requirements of the Code. In designing exploration programs, interest holders are required to implement measures to minimise the potential for emissions. It is noted that the method of drilling selected by the interest holder negates the need for flaring, because using an overbalanced mud system for drilling keeps the produced water and the gas in the formation during drilling, thereby minimising emissions to the greatest extent possible at this stage of exploration. The interest holder has also committed to real-time gas-detection during drilling. The NT government is also currently preparing its climate change and environmental offsets policies.
4. *Water*: Public submissions raised concerns about contamination of ecologically important temporary or permanent waterbodies from spilt contaminants, downstream impacts to the Towns River, Magaranyi River, Cox River, Mantungula Creek, Lagoon Creek, Tanumbirini Creek,

October Creek and Limmen Bight River from transport of chemicals and waste, impacts to water security, contamination of groundwater via sulfide corrosion impacting well integrity and impacts to the Moroak Sandstone aquifer. Appendix H of the revised EMP includes detailed spill modelling, to illustrate the likelihood of a spill causing contamination of surface or groundwater. Noting the soil structures at the location of the regulated activity (silty claystone and siltstone in the top 50 m and limestone below), the study concluded that a 1,000 L spill of oil would take ~ 690 years to infiltrate to the limestone soils, where it may then have an impact on the Gum Ridge aquifer. Similarly, a 1,000 L spill would form a 5 cm pool of radius 17 m and commence infiltration within 2 hours. As the Code requires an immediate response to any contamination detected, a spill management plan for spills of hazardous materials, and primary and secondary containment for all potentially hazardous materials stored, the risk of causing offsite contamination of surface waters is considered unlikely.

Risks to offsite surface water bodies associated with transport of wastewater is addressed under 'Social and cultural', above.

Issues related to water security are addressed in 'Regulation and compliance', below. It is further noted the NT government has recently established the Office of Water Security, which is tasked with developing the NT Strategic Water Plan.

In accordance with clause B.4 of the Code, all onshore shale gas wells (including exploration wells constructed for the purposes of production testing) have mandatory requirements for well construction, with cementing extending up to at least the shallowest problematic hydrocarbon-bearing, organic carbon rich or saline aquifer zone. The interest holder must have a Well Operations Management Plan (WOMP) accepted prior to commencement of the activity, that will be implemented for the drilling program design to ensure isolation of the Gum Ridge Formation and overall petroleum well integrity is achieved. These measures to be implemented, as specified in the Code, include:

- development of critical controls and hold points throughout the well construction process that will need verification by a competent person prior to proceeding to the next operation
- barrier verifications and monitoring throughout well construction, maintaining primary and secondary well control measures
- a cemented production casing string that will provide an additional barrier between producing hydrocarbon bearing zones and shallow aquifers, with pressure testing once the cement is set to ensure overall integrity of the production casing
- multiple strings of steel casing with each casing string cement grouted to the surface and multiple engineered and system mitigations to adequately detect water quality threats to the Cambrian Limestone Aquifer (and the deeper, saline Moroak Sandstone, which lies beneath the lower Kyalla Formation)
- well barrier integrity validation testing for each well with a report demonstrating compliance with the Code to be provided to the regulator for approval.

Increasing salinity and temperature with depth below surface is a general feature of all sedimentary basins including the Beetaloo Sub-basin. In conventional petroleum reservoirs a salt "top seal" is a common feature of the stratigraphic trap that causes hydrocarbons to accumulate. The risk of corrosion as a result of increased salinity and temperature is therefore not unique to unconventional (e.g. shale) petroleum exploration and production. However, petroleum wells are designed with multiple barriers, as required by the Code, so that a single barrier failure will not lead to a loss of containment or in this case aquifer contamination. As such, petroleum wells are highly engineered underground "pressure vessels". Complete well integrity failure where all well barriers fail is an extremely rare occurrence in contemporary petroleum wells, including shale wells. International failure rate is estimated at less than 1 in 10,000 wells.² Moreover, a recent study on well integrity of CSG wells in Queensland, Australia, covering the period 2010-2015 concluded that the risk of a subsurface breach of a well integrity

² King GE and DE King, 'Environmental Risk Arising From Well Construction Failure: Differences between Barrier Failure and Well Failure, and Estimates of Failure Frequency Across Common Well Types, Locations and Well Age' (2013) 29(4) *Society of Petroleum Engineers Production and Operations*, doi:10.2118/166142-PA.

was assessed to be “very low to near zero”.³ The 2019 document cited in the submission in relation to coal seam gas wells in Queensland dates back to 2016 and is not a new issue arising since the HFI.

The necessary ingredients for upward flow are an upward head gradient (pressure) or driving force and a leakage pathway. In order for upward flow to occur, the head gradient must be large enough to overcome density gradients associated with increasing salinity with depth and these upward head gradients would need to be sustained over thick sequences (typically >1000 m) to drive a significant amount of brine from the Moroak into shallow fresh groundwater. The source formation (Moroak) must also have sufficient fluid that exists in the pore space (porosity) and is also permeable enough to provide a driving force in a potential leakage pathway. Rate of progress (ROP) during drilling through the Moroak formation at Carpentaria-1 well was extremely low, as reported elsewhere in the Beetaloo, indicating a very high degree of cementation in the Moroak and this supports the fact that it has acted as a barrier to any upward migration of hydrocarbons from the target Velkerri shale over millions of years and also prevents any potential hydraulic fracture upward growth from the target Velkerri formation. The high degree of cementation (extremely low porosity) evident in the Moroak due to difficulty in drilling through it, also precludes the likelihood of any significant water production from the Moroak. In addition, there was no evidence of over-pressure during drilling through the Moroak sandstone at Carpentaria-1 well, as evidenced by the drilling and mud logs for the Carpentaria-1 well. Overpressure is necessary for upward flow. The likelihood that pollutants will be moved to other aquifers is therefore considered remote.

Regardless of the driving mechanism, flow rates are low and timescales for transport are long (often >10⁶ years). The effective hydraulic isolation of these formations is demonstrated by the fact that fluids have been trapped at depth for tens to hundreds of millions of years.⁴

The revised EMP focusses on drilling and does not include hydraulic fracturing as part of the regulated activity. Reference to hydraulic fracturing in the EMP is in the context of stakeholder engagement, which necessarily included discussion of the whole of the intended work program of the interest holder, such that stakeholders are aware of the future as well as current proposed activities.

5. *Waste*: Public submissions raised concern about wet season overtopping of wastewater storage ponds. Storage tanks and pits are designed and operated to prevent overtopping due to rainfall and drill cutting sumps include sufficient freeboard to accommodate in excess of the anticipated rainfall based on a 1:1000-year Average Recurrence Interval (ARI) for the duration of the regulated activity. The revised EMP includes specific measures should drilling be required to continue into the wet season, including sumps with more than four times the required capacity for drill cuttings, and an additional 0.3 m bund on top of the sump walls, to prevent overflow stormwater entering the sumps in a 1 in 100 year rainfall event. Further, calculation of required freeboard (1,500 mm in the wet season) was based on a detailed assessment of rainfall and evaporation rates for the region (Appendix G), and informed by flood modelling (section 4.1.7.1 of the revised EMP). The risk of overtopping is considered unlikely.
6. *Human health*: Concerns were raised about impacts to human health through use of toxic chemicals. Mitigation of potential exposure pathways to humans from the regulated activity, as well as other occupational health and safety considerations for workers (e.g. heat stress) are typically addressed in the company and service provider’s health and safety procedures. All interest holders must comply with NT occupational health and safety legal requirements, which includes exposure to chemicals and transportation of dangerous goods, under legislation and regulations administered by NT WorkSafe. The interest holder has committed to testing drilling waste and drilling waste with elevated naturally occurring radioactive material or other contaminants will be considered a listed waste and therefore will be managed under listed waste provisions of the *Waste Management and Pollution Control Act 1998* (NT).

³ Wu B, R Doble, C Turnadge and D Mallants (CSIRO) (2016) *Well Failure Mechanisms and Conceptualisation of Reservoir-Aquifer Failure Pathways*. SPE Asia Pacific Oil & Gas Conference and Exhibition, 25-27 October, Perth, Australia.

⁴ Flewelling S and M Sharma, ‘Constraints on upward migration of hydraulic fracturing fluid and brine’ (2014) 52(4) *Groundwater* 492-4.

Public submissions requested all chemicals that pose risks to aquatic life be banned and were also concerned with disclosure of Chemical Abstracts Service (CAS) numbers of chemicals and recommended the NT government require that manufacturers conduct health testing before chemicals can be manufactured. In response to the submissions, the revised EMP was updated to include the CAS numbers of all drilling fluids proposed to be used. The Code provides requirements relating to handling, storing, using and disposing of all chemicals proposed to be used for petroleum activities such that the potential and actual impacts and risks are managed to as low as reasonably practical and acceptable levels. The revised EMP provides demonstration that these requirements will be met, through adequate consideration of transportation risks (including during the wet season), storage requirements, spill management and use of licensed waste contractors for disposal of waste chemicals.

7. *Regulation and compliance:* Public submissions raised concerns about fragmented approvals, lack of transparency and scientific scrutiny, cumulative impacts, consideration of direct and indirect impacts and referral under the *Environment Protection Act 2019* (NT) (EP Act) and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Regulations allow for an EMP to include a single or multiple regulated activities. This reflects the nature of exploration programs, in which outcomes from different phases of exploration are a key determinant of the nature and scale of future work programs. However, the NT EPA recognizes that multiple EMPs for the same project impose an extra burden on the regulator and the NT EPA, and encourages the submission of a consolidated EMP.

All EMPs that relate to drilling or hydraulic fracturing are subject to 28-day public consultation, and their availability for public review is also advertised. All EMPs are also subject to review by NT government agencies, including by specialists in fauna and flora, water quality and quantity, land, bushfire, weeds, traffic, public health and social impacts.

The revised EMP considers cumulative impacts. Traffic increases are considered negligible, and the interest holder has invested in upgrades at intersection of the site access road and the Carpentaria Highway. Groundwater use is subject to the requirements of the *Water Act 1992* (NT) and the interest holder has obtained a water extraction licence, which included a detailed assessment of resource availability by DEPWS. In granting the licence, the Controller of Water Resources noted the grant will not have an unreasonable impact on the existing and likely future demand for water for domestic purposes in the area and extraction would create no change in reliability of spring flows at Bitter Springs or Rainbow Springs (groundwater dependent ecosystems). Predicted greenhouse gas emissions have been considered in the context of all aspects of the regulated activity in the revised EMP as well as previous activities, and includes a comparison of predicted and actual, for activities already completed under the original drilling EMP.

The interest holder has undertaken an analysis of the potential for the regulated activity to have a significant impact on matters of national environmental significance (MNES) defined under the Commonwealth EPBC Act, and the environmental values defined under the EP Act (NT) and has determined there is no potential for a significant impact which would require referral under either statute, with the proposed controls implemented. The assessment of MNES is considered comprehensive and is based on field-based assessments and desktop assessments for a 10 km radius around the actual footprints of the activity at Inacumba and Tanumbirini locations within EP161.

6. Other relevant matters

Regulation 9 requires that an EMP provides a comprehensive description of the regulated activity, including provision of a detailed timetable for the activity. The EMP includes an estimate of duration of the regulated activity. The NT EPA recommends the interest holder be required to submit an updated timetable for the regulated activity to DEPWS, on a quarterly basis.

CONCLUSION

The NT EPA considers that, subject to the consideration of the recommended EMP approval conditions, the EMP:

- is appropriate for the nature and scale of the regulated activity
- demonstrates that the regulated activity can be carried out in a manner that potential environmental impacts and environmental risks of the activity will be reduced to a level that is as low as reasonably practicable and acceptable.

In providing this advice the NT EPA has considered the principles of ecologically sustainable development.

RECOMMENDATION

The NT EPA recommends that should the EMP for Santos QNT Pty Ltd be approved, the following conditions be considered:

Condition 1: The interest holder must submit to the Department of Environment, Parks and Water Security (DEPWS), via Onshoregas.DEPWS@nt.gov.au:

- i. a timetable for the regulated activity that is to be provided prior to the commencement of the activity and each quarter thereafter, or more frequently should other constraints, such as seasonal weather forecasts or travel restrictions emerge, and including:
 - time-bound commitments in the EMP
 - due dates for satisfaction of Ministerial approval conditions
 - due dates for regulatory reporting; and
- ii. daily on-site reports indicating the status and progress of drilling, and the freeboard available in drilling sumps (in ML); and
- iii. a seven-day activity forecast for the duration of the activity during the wet season (1 October – 30 April each year); and
- iv. written notification of any halt to the activity due to wet season conditions, within 24 hours of the halt; and
- v. immediate written notification of any fires potentially threatening the activity from external or internal sources; and
- vi. weekly reports that detail the outcome of site inspections, and corrective actions taken, and inclusive of all commitments in the approved EMP, from the commencement of the regulated activity and continuing while the EMP remains in force.

Condition 2: In the event of any accidental release of contaminants that exceeds 200 litres (for liquids), the interest holder must provide a written report to DEPWS, via Onshoregas.DEPWS@nt.gov.au, as follows:

- i. within 24 hours, provide a written report with details of the incident specifying material facts and actions taken to avoid or mitigate environmental harm; and
- ii. within 14 days of the incident, provide a written report detailing:
 - a. the volume of impacted soil removed for appropriate disposal and the depth of any associated excavations; and
 - b. the corrective actions taken or proposed to be taken to prevent recurrence of an incident of a similar nature.

Condition 3: The interest holder must provide an annual report to DEPWS, via Onshoregas.DEPWS@nt.gov.au, on its environmental performance, in accordance with item 11(1)(b) in schedule 1 of the Petroleum (Environment) Regulations 2016 (NT). The first report must cover the 12 month period from the date of the approval, and be provided within three calendar months of the end of the reporting period. The annual environmental performance report must align with the template prepared by DEPWS for this purpose.

Condition 4: An emissions report must be provided to DEPWS by 30 September each year, via Onshoregas.DEPWS@nt.gov.au, which summarises actual annual greenhouse gas emissions reported under the Commonwealth *National Greenhouse and Energy Reporting Act 2007* versus predicted emissions in the EMP.⁵

Condition 5: In line with the approval conditions previously applied to the McArthur Basin drilling program, the interest holder must provide to DEPWS, via Onshoregas.DEPWS@nt.gov.au, a cementing report for the surface casing (13 3/8") through the aquifers, as soon as practicable but not more than fourteen (14) days after completion of the cementing job for each well.

Condition 6: In line with the approval conditions previously applied to the McArthur Basin drilling program, the interest holder must provide to DEPWS, via Onshoregas.DEPWS@nt.gov.au, a Rapid Response Site Demobilisation and Stabilisation Plan that details the strategy for managing environmental risks, including management of drill cuttings, that may result in the event of a flood event at both the Tanumbirini and Inacumba well sites, within 2 months of approval of the EMP.

Condition 7: In line with the approval conditions previously applied to the McArthur Basin drilling program, the interest holder must provide to DEPWS, via Onshoregas.DEPWS@nt.gov.au, the following:

- i. results of groundwater monitoring from the Inacumba Unit at the Inacumba well site, in accordance with the Code and the *Preliminary Guideline: Groundwater Monitoring Bores for Exploration Petroleum Wells in the Beetaloo Sub-basin* (DENR, 2018) every quarter for three years from the approval date of the EMP for publishing on the DEPWS website, in a format to be provided by DEPWS; and
- ii. results of continuous water level monitoring using water level loggers installed at the monitoring bores in the Inacumba Unit at the Inacumba well site, every quarter for three years for publishing on the DEPWS website, in a format to be provided by DEPWS; and
- iii. results of groundwater monitoring from the Gum Ridge Formation at the Tanumbirini well site, in accordance with the Code and the *Preliminary Guideline: Groundwater Monitoring Bores for Exploration Petroleum Wells in the Beetaloo Sub-basin* (DENR, 2018) for the period the well sites are operational, for publishing on the DEPWS website, in a format to be provided by DEPWS.

Condition 8: In support of clause B.4.17.2 of the Code, the interest holder must provide to DEPWS, via Onshoregas.depws@nt.gov.au, an interpretative report of groundwater quality based on the groundwater monitoring required to be conducted at the well site(s) in accordance with Table 6 of the Code. The interpretative report must be provided annually within three months of the anniversary of the approval date of the EMP and include:

- i. demonstration that there is no change to groundwater quality or level attributable to conduct of the regulated activity at the well site(s);
- ii. interpretation of any statistical outliers observed from baseline measured values for each of the analytes;
- iii. discussion of any trends observed; and
- iv. a summary of the results inclusive of descriptive statistics.

⁵ Clause D.6.2(b) of the Code requires annual actual greenhouse gas emissions to be provided even where emissions are below the NGERs threshold of 25 ktCO₂-e for scope 1 and scope 2 emissions reporting.

Condition 9: In line with the approval conditions previously applied to the McArthur Basin drilling program, and in support of clause of the Code, the interest holder must provide to DEPWS, via Onshoregas.DEPWS@nt.gov.au, no later than three months of completion of the drilling program, a report that:

- i. provides the outcome of assessment and leachability testing of residual drill fluids and drill cuttings; and
- ii. provides the recommended disposal option.

A handwritten signature in blue ink, appearing to read 'P. Vogel', with a horizontal line underneath it.

DR PAUL VOGEL AM

CHAIRPERSON

NORTHERN TERRITORY ENVIRONMENT PROTECTION AUTHORITY

19 FEBRUARY 2021