Appendix E: Weed Management Plan

Weed Management Plan

2019-20 Hydraulic Fracture Stimulation program - EP 161

Santos

www.ecoz.com.au

DOCUMENT CONTROL RECORD

Job	EZ19175
Document ID	182238-30
Author(s)	Felicity Watt

DOCUMENT HISTORY

Rev	Reviewed by	Approved by	Issued to	Date
1	D. van den Hoek	R. Hall	Client	19/09/2019

Recipients are responsible for eliminating all superseded documents in their possession.

EcOz Pty Ltd.
ABN: 81 143 989 039
Winlow House, 3rd Floor
75 Woods Street
DARWIN NT 0800
GPO Box 381, Darwin NT 0800

Telephone: +61 8 8981 1100
Facsimile: +61 8 8981 1102
Email: ecoz@ecoz.com.au
Internet: www.ecoz.com.au

APPROVED COMPANY AS/NZS 4801 OH&S Management Systems QMS Certification Services

APPROVED COMPANY ISO 9001 Quality Management Systems QMS Certification Services

APPROVED COMPANY ISO 14001 Environmental Management Systems QMS Certification Services

TABLE OF CONTENTS

Appendices

Tables

Figures

1 INTRODUCTION

Santos owns and operates onshore shale gas exploration permit (EP) 161, and has undertaken exploration activities there since 2013. The EP straddles the Carpentaria Highway, approximately 350 km south-east of Katherine. Approval was received from the NT Department of Environment and Natural Resources (DENR) in 2019 to undertake civil works and infrastructure development at the Tanumbirini 1/2H and Inacumba 1/1H well leasepads. A weed management plan was prepared as part of the development of the approval process. (EcOz, 2019a)

Further to this work Santos propose a Hydraulic Fracturing Stimulation (HFS) program to be conducted through 2019-2020 at these well locations, with the aim of improving understanding of the potential of EP 161. Surface disturbance additional to that covered under the civil works and infrastructure development will involve drilling of approximately 50 shallow holes for surface tiltmeter installation around each wellsite, and surface site preparation for installation of passive seismic monitoring equipment (Santos, 2019). These works will be regulated through an environmental management plan (EMP) approved by DENR. EcOz were engaged to prepare an associated weed management plan – this document – required as a component of the EMP under the *Petroleum (Environment) Regulations* (the Regulations).

1.1 Scope & objectives

The scope of this weed management plan is to outline the weed management measures that will be implemented to prevent the introduction and spread of weeds during the works associated with the HFS.

The objectives of this weed management plan are to:

- Comply with all applicable legislation, regulations, conditions and regional weed management plans.
- Address the specific weed management requirements of station owners.
- Provide controls for HFS activities to avoid introducing new weed species into the 2019-2020 HFS program footprint.
- Avoid or control the spread of existing weed species into new areas within the 2019-2020 HFS program footprint.
- Detail the monitoring, reporting and incident response procedures appropriate for the management measures.

The weed management plan is applicable to all activities associated with the 2019-2020 HFS program, and will be used by all personnel (including contractors) involved in program activities.

1.2 Dedicated weed officer

The *Scientific Inquiry into Hydraulic Fracturing* recommended a dedicated weed officer for each gas field. Contact details for Santos' weed officer for EP 161 are:

Mitch Bird, Senior Environmental Advisor, Tel: 07 3838 3799, Email: mitch.bird@santos.com

1.3 Site activities and project footprint

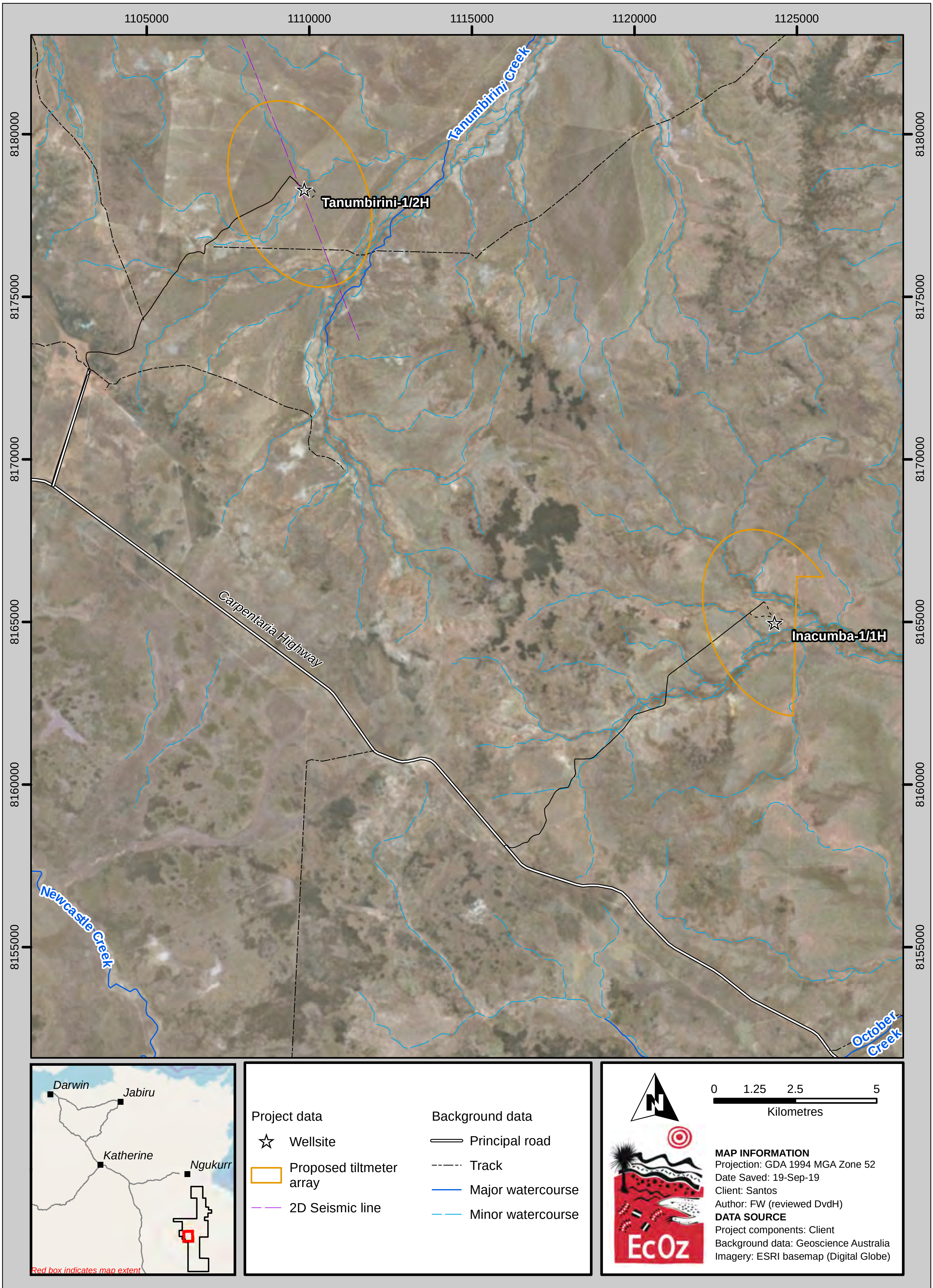
Activities associated with the HSF program include:

- Fracture stimulation preparation, evaluation and monitoring activities at Tanumbirini 1/2H and Inacumba 1H wellsites
- Vertical seismic profiling along a 10 km 2D seismic line

- Drilling of approximately 50 shallow holes (to approximately 12 m in depth) for surface tiltmeter installation around each wellsite.
- Surface site preparation for installation of approximately four passive seismic monitoring stations around each wellsite. This will include digging of at least one 300 mm x 300 mm hole at each site.
- Access will be via existing roads or tracks. Access for any sites remote from existing roads or tracks will be light vehicle only and not require any tree clearing.

The 2019-2020 HFS program footprint is mapped in Figure 1-1 and consists of:

- Two 6 km by 4 km ellipses centred around the Tanumbirini 1/2H and Inacumba 1/1H wellsites, within which the tiltmeters and passive seismic monitoring stations will be situated.
- 10 km 2D seismic line



Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\Santos_Tanumbirini\EZ19175 - E161 HFS EMP aspects\01 Project Files\Report maps\Figure 1-1. Map showing 2019-2020 HFS program footprint.mxd

Figure 1-1. Map showing 2019-2020 HFS program footprint

2 LEGAL REQUIREMENTS

This following legislation, statutory obligations and guidelines were considered during the preparation of this weed management plan.

2.1.1 Petroleum (Environment) Regulations

The Petroleum (Environment) Regulations, (the Regulations), require submission of an EMP prior to any petroleum exploration or production activity. This weed management plan represents a component of the 2019 Hydraulic Fracturing program EMP, as required under the regulations.

2.1.2 Weeds Management Act

This Act aims to:

> *Protect the Territory's economy, community, industry and environment from the adverse impact of weeds*

It declares undesirable species of plants as weeds, and requires these species to be controlled, eradicated or prevented from entering the Northern Territory (NT) depending on their classification. Under the Act, weeds are classified into one of three classes:

- Class A declared plant – to be eradicated
- Class B declared plant – growth and spread to be controlled
- Class C declared plant – not to be introduced into the NT (all Class A and B weeds are also Class C)

The Act specifies how weeds in each of the classes must be treated. Weed management plans for specific weeds are endorsed under this Act.

2.1.3 Management plans and guidelines

Statutory Weed Management Plans

These plans are legal documents containing specific information about management requirements for certain high priority weeds. Section 4 lists weeds that are present or have the potential for introduction onto EP 161, and notes those with an associated statutory weed management plan.

Guidelines and standards

The following guidelines associated with the management of weeds in the NT have also been considered during the preparation of this WMP:

- *Northern Territory Weed Management Handbook* (Weed Management Branch, 2015a)
- *Northern Territory Weed Data Collection Manual* (Weed Management Branch, 2015b)

2.1.4 Santos environmental policy

Santos' Corporate Environmental Policy is a public declaration of its understanding of the environmental impacts and risks associated with its operations, as well as a demonstration of its compliance with all relevant environmental, health and safety regulations, legislation and guidelines. A copy is provided as Appendix A.

3 WEED RISK MITIGATION MEASURES

The EMP risk assessment process identified a number of weed introduction and/or spread risks associated with the scope of this plan. Table 3-1 documents these risks as well as the mitigation measures that will be implemented to reduce this risk.

Table 3-1 Weed risk and mitigation measures

Weed risk	Mitigation measures	Measurement criteria	Responsible
Introduction of new weed species to EP 161 from plant and vehicles.	All vehicles / machinery /equipment entering the EP to be cleaned and free of soil and vegetative matter, and have a valid weed hygiene declaration	A register of vehicle / equipment / machinery inspection is kept.[1] Spot checks on vehicle / equipment / machinery to ensure inspections are completed correctly	Santos Dedicated Weed Officer
	Site environmental inductions for all personnel and contractors to include vehicle weed hygiene requirements	All project staff undertake an environmental induction, to be recorded in the Santos Training Register	Santos Dedicated Weed Officer
Weed spread in EP 161 resulting from vehicles/plant traversing existing weed infestations	All infestations of declared weeds mapped; all personnel and contractors made aware of existing infestation locations and trained in the identification of existing weeds	All project staff undertake an environmental induction, to be recorded in the Santos Training Register Weed maps and factsheets included as part of environmental induction All operational staff to attend weed identification training delivered by the NT Weed Management Branch	Santos Dedicated Weed Officer
	All vehicles, machinery and equipment to stay on formed access tracks, except for those involved in clearing	All project staff undertake an environmental induction, as recorded in the Santos Training Register	Santos Dedicated Weed Officer
	If infestations are identified during the 2019 program they will be demarcated and avoided, where possible, via a detour around the infestation	Maintain demarcation during operations and inspect (and rectify if needed) daily	Santos Field Representative
	If infestations cannot be avoided, treat prior to traversing using methods set out in Table 5-1. Vehicles/plant to be cleaned and free of soil and vegetative matter prior to moving beyond infestation	Work plan to reflect additional tasks required Spot checks on vehicle / equipment / machinery to ensure inspections are completed correctly	Santos Field Representative / Santos Dedicated Weed Officer

[1] Weed hygiene declaration included as Appendix B.

Weed risk	Mitigation measures	Measurement criteria	Responsible
Existing weed distribution not fully known due to survey conducted outside of prime growth period	Further monitoring to be undertaken, as set out in Section 6 of this document	Annual reporting against this WMP, as per Section 6.3	Santos Dedicated Weed Officer

4 WEED SPECIES

Baseline surveys for weeds within the 2019 civil and seismic program footprint were undertaken in August and November 2018 and in May 2019 (EcOz, 2019b & 2019c). Surveys focused along access tracks, within a 500 m buffer around the proposed wellsites, within the proposed borrow pit locations, and 40 km of linear transects radiating from Tanumbirini-2.

Additional weed survey was undertaken in September 2019 to ensure adequate coverage of the HFS program footprint. Survey coverage is shown in Figure 4-1; full details of this survey are contained in the associated weed survey report (EcOz, 2019d).

Declared weed species recorded within and in proximity to the HFS program footprint are listed in Table 4-1, with locations mapped in Figure 4-2.

Table 4-1. Declared weed species recorded on EP 161

Common name	Scientific name	NT Class	HFS Footprint
Hyptis	*Hyptis suaveolens*	B/C	Y
Rubber Bush[2]	*Calotropis procera*	B/C	
Spinyhead sida	*Sida acuta*	B/C	Y
Flannel weed	*Sida cordifolia*	B/C	Y
Sicklepod	*Senna obtusifolia*	B/C	Y

Other weed species with the potential to occur in the region more broadly, and considered as part of this plan are shown below in Table 4-2.

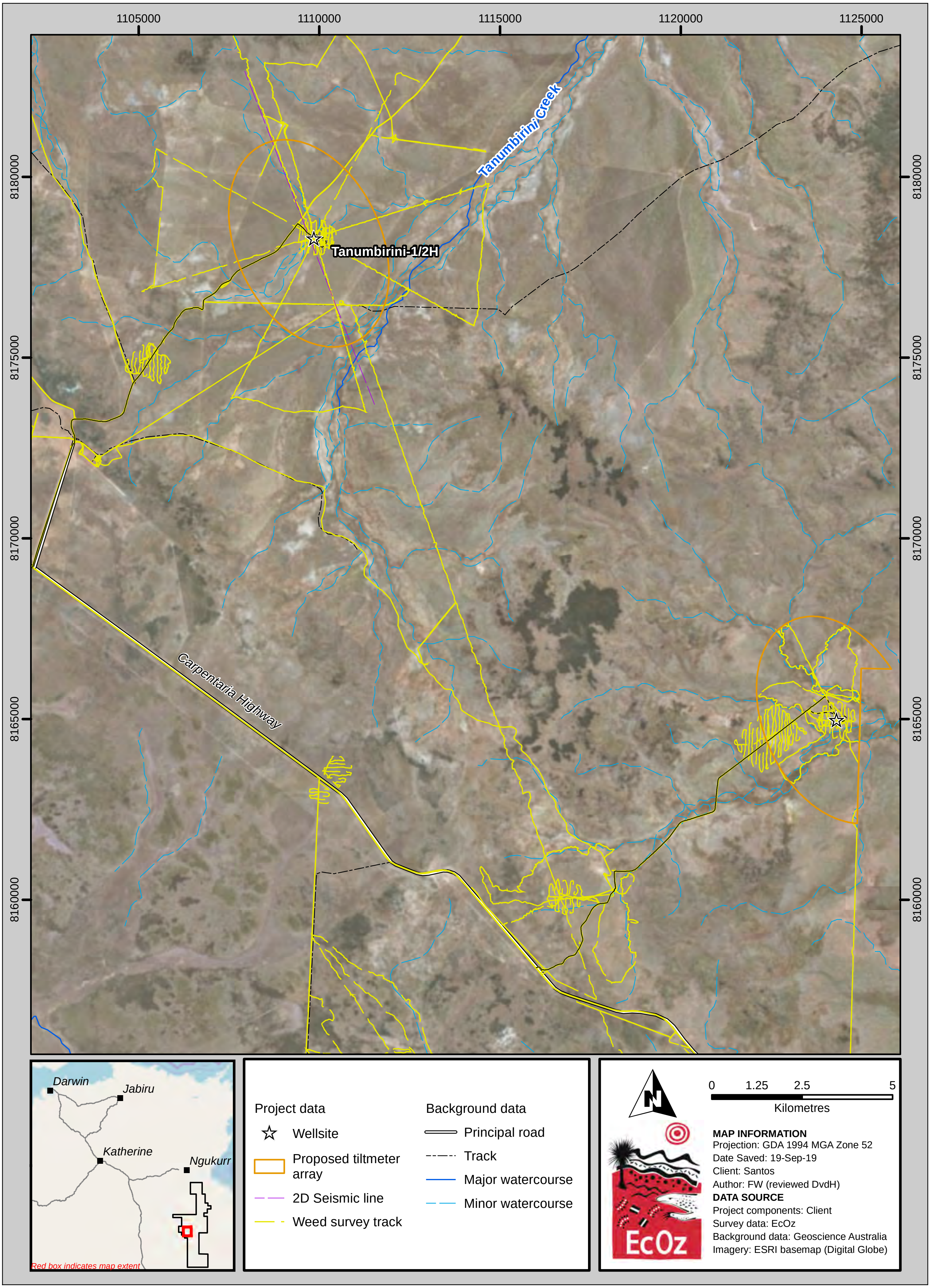
[2] Although Rubber Bush is only declared south of 16°30' S, it was included in this list as current exploration areas are just north of this latitude and the exploration permit area crosses this line of declaration

Table 4-2. Other weeds with potential to occur on EP 161

	Common name	Scientific name	NT Class	WoNS
Katherine region priority weeds	Mesquite*	*Prosopis spp.*	A/C	Y
	Prickly acacia*	*Vachellia nilotica*	A/C	Y
	Parkinsonia	*Parkinsonia aculeata*	B/C	Y
	Chinee Apple*	*Ziziphus mauritiana*	A/C	
	Mimosa*	*Mimosa pigra*	A/C	Y
	Bellyache Bush*	*Jatropha gossypiifolia*	A/C[3]	Y
	Gamba Grass*	*Andropogon gayanus*	A/C	Y
	Neem*	*Azadirachta indica*	B/C	
	Grader grass*	*Themeda quadrivalvis*	B/C	Y
	Snake weed	*Stachytarpheta spp.*	B/C	
	Devils Claw	*Martynia annua*	A/C	
Other declared weeds	Parthenium[4]	*Parthenium hysterophorus*	A/C	Y
	Starburr	*Acanthospermum hispidum*	B/C	
	Mossman River Grass	*Cenchrus echinatus*	B/C	
	Paddy`s Lucerne	*Sida rhombifolia*	B/C	
	Caltrop	*Tribulus terrestris*	B/C	
	Noogoora Burr	*Xanthium strumarium*	B/C	
	Khaki Weed	*Alternanthera pungens*	B/C	

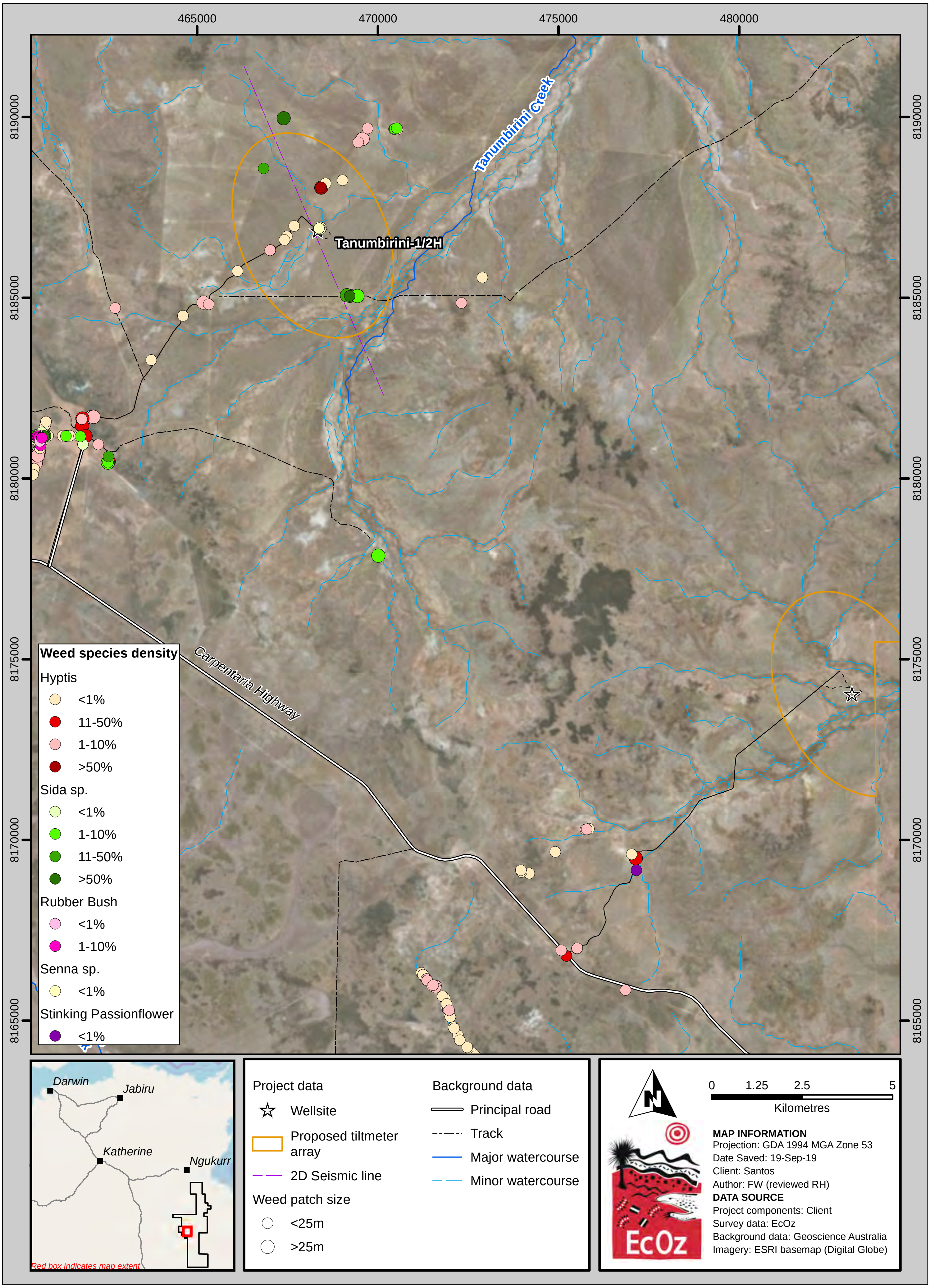
* indicates weeds with an associated weed management plan

[3] Bellyache bush classification depends on its location within the NT; the EP is within the Class A eradication zone
[4] Parthenium, previously eradicated from the NT, has recently been recorded in the Katherine Weed Management region



Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\Santos_Tanumbirini\EZ19175 - E161 HFS EMP aspects\01 Project Files\Report maps\WMP Figure 4-1. Map showing survey coverage within the 2019-2020 HFS program footprint.mxd

Figure 4-1 Map showing survey coverage within and around the 2019-2020 HFS program footprint



Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\Santos_Tanumbirini\EZ19175 - E161 HFS EMP aspects\01 Project Files\Report maps\WMP Figure 4-2. Map showing weed occurrences within or adjacent to the project area.mxd

Figure 4-2 Map showing weed occurrence within or adjacent to the 2019-2020 HFS program footprint

5 ANNUAL ACTION PLAN

The annual action plan in Table 5-1 details the survey and control activities for weeds recorded within EP 161.

Table 5-1. Annual action plan

Weed Management Area	Weed species	Management objective	Survey / monitoring time/s	Treatment time/s	Control method/s	Herbicide
Tanumbirini- 1/2H HFS footprint	Sicklepod	No spread	End of wet season – March depending on site access	End of wet season – March depending on site access	Foliar spray seedlings and adults	Dicamba
	Hyptis	No spread				2, 4-D amine 625 g/L
	Sida sp.	No spread				
2D Seismic line	Hyptis	No spread	End of wet season – March depending on site access	End of wet season – March depending on site access	Foliar spray seedlings and adults	2, 4-D amine 625 g/L
	Sicklepod	No spread				Dicamba 500 g/L
Tanumbirini Access tracks	Spinyhead sida	No spread	End of wet season – March depending on site access	End of wet season – March depending on site access	Foliar spray seedlings and adults	2, 4-D amine 625 g/L
	Hyptis	No spread				
Inacumba 1/1H HFS footprint	No weeds	Prevent the introduction of weeds	End of wet season – March depending on site access	Immediately if weeds are found	Refer to the NT Weed Management Handbook	
Inacumba Access Tracks	Hyptis	No spread	End of wet season – March depending on site access	End of wet season – March depending on site access	Foliar spray seedlings and adults	2, 4-D amine 625 g/L

Treatment times, control methods have been taken from the NT Weed management handbook – refer to the handbook for herbicide application rates

6 WEED MONITORING

The requirements for weed monitoring within each component of the project area are outline above in Section 5. Additional to the survey / monitoring times listed in Table 5-1, monitoring for weed incursions will be ongoing during operations, as all operational staff will have a responsibility to report new weed incursions to Santos' dedicated weed officer. Should new weed incursions be identified during monitoring, control will be undertaken during recommended treatment times, and follow-up surveys will be within three months to ensure effective eradication of the incursions.

Upon completion of equipment installation, the potential for weed spread within the project area should be largely reduced to access tracks including those used to access the passive seismic monitoring stations, the 2D seismic line, and wellsite infrastructure. To target survey efforts within areas at high risk of weed establishment, weed monitoring will focus on the following areas:

- Known weed locations
- Along access tracks
- 2D seismic line
- 50 m buffer around stock watering points traversed by access tracks
- 50 m buffer around wellsite and seismic monitoring infrastructure
- Any other areas that were disturbed during track, seismic line, or well construction, or tiltmeter installation. Sites that have been rehabilitated will be surveyed on foot.

6.1 Notification procedure

All new weed incursions will be reported to the NT Weed Management Branch by Santos' dedicated weed officer. Initial notification will be verbal, followed by written notification of preliminary species identification and location within seven working days.

6.2 Recording

All weed monitoring and survey activities will be recorded in accordance with the NT Weed Data Collection Guidelines available at: https://nt.gov.au/environment/weeds/weed-mapping-and-data-sharing.

The following attributes of any new weed infestations will be recorded into a GPS enabled device:

- Site ID
- Weed name
- ID confidence
- Date of record
- Coordinate information
- Recorder / organisation
- Infestation size
    - 5 m diameter
    - 20 m diameter
    - 50 m diameter
    - 100 m diameter
- Infestation density
    - 1 = Absent, no weeds of this species in the area
    - 2 = < 1%; very few, not many weeds
    - 3 = 1 – 10%; more than one or two isolate plants
    - 4 = 11 – 50%; Many plants, covering up to half the area

- o 5 = > 50%; Weed forms the dominant cover

Weed data will be submitted as an excel spreadsheet to the Weeds Management Branch (refer Appendix C for an example template).

6.3 Reporting

Santos' weed management officer will submit annual reporting against this WMP as a component of the EMP environmental reporting requirements. This will include

- Details of activities implemented to address weed spread and introduction risks
- Submission of all weed data collected
- Details of survey and monitoring events, including dates, personnel, maps and track data
- An overview of weed control events and success rates

This annual report will be reviewed by the NT Government's Onshore petroleum weed management officer.

7 REFERENCES

EcOz (2019a) *Weed Management Plan, 2019 Exploration Program – EP 161* Report produced by EcOz Environmental Consultants for Santos as part of EMP: McArthur Basin Civil and Seismic Program

EcOz (2019b) *Ecology Report, 2019 Exploration Program*. Report produced by EcOz Environmental Consultants for Santos

EcOz (2019c) *2019/2020 Exploration Program EP 161 Weed Survey Report 2019*. Report produced by EcOz Environmental Consultants for Santos

EcOz (2019d) *Santos EP 161 Hydraulic Fracturing Weed Surveys, September 2019*. Report produced by EcOz Environmental Consultants for Santos.

Santos (2019), *Environment Management Plan: McArthur Basin 2019 Hydraulic Fracturing Program. NT Exploration Permit 161.*

Weed Management Branch 2015a, *Northern Territory Weed Management Handbook*, Department of Land Resource Management, Northern Territory Government, Darwin

Weed Management Branch 2015b, *Northern Territory Weed Data Collection Manual*, Department of Land Resource Management, Northern Territory Government, Darwin

APPENDIX A SANTOS CORPORATE ENVIRONMENTAL POLICY

Environment, Health and Safety

Santos

Policy

Our Commitment

Santos is committed to a workplace where we all go home without injury or illness and manage the impact of our operations on the environment.

Our Actions

We will:

1. implement a structured and systematic approach to environmental, health and safety management and monitor its effectiveness
2. include environmental, health and safety considerations in business planning and decision-making processes
3. understand and manage the impact of our operations on the environment
4. comply with all relevant environmental, health and safety laws
5. promote a strong and consistent safety culture across all aspects of business
6. work pro-actively and collaboratively with our stakeholders and the communities in which we operate
7. set, measure and review objectives and targets which drive continuous improvement
8. report publicly on our environmental, health and safety performance

Governance

The Environment Health Safety & Sustainability Committee is responsible for reviewing the effectiveness of this policy.

This Policy will be reviewed at appropriate intervals and revised when necessary to keep it current.

Kevin Gallagher

Managing Director & CEO

Status: APPROVED

Document Owner:	Naomi James, Executive Vice President, EHS & Governance		
Approved by:	The Board	Version:	1

APPROVED 28 October 2016 Page 1 of 1

APPENDIX B WEED HYGIENE DECLARATION

Weed Hygiene Declaration

This declaration is valid for transport and movement of vehicles and equipment from [ ] to [ ] (provide locations) and will stay current pursuant to the definition of clean in Definitions.

VEHICLE DESCRIPTION

Make: [ ] Registration # or engine number: [ ]

Was clean prior to entry to [ ] (destination)

Add equipment examined to the Equipment Register

Certifier name [ ]

Certifier qualification [ ] Qualification date [ ]

DECLARATION

I, [ ] (name),of [ ] (street)

[ ] town [ ] state [ ] telephone

declare the information I provided in this declaration is true and correct and I have read the accompanying explanatory notes before completion of this declaration.

Signature [ ] Date [ ]

EXPLANATORY NOTES

This certification process was developed to fulfill one of the stated purposes of the NT *Weed Management Act* and the Qld Land Protection *(Pest and Stock Route Management) Act 2002*.

It applies to, as a minimum, all weeds listed as weeds in the relevant jurisdiction and any plants that a stakeholder does not want transported or introduced.

DEFINITIONS

Clean:

- Means that no soil or organic matter is present on vehicles or equipment
- Vehicles and equipment are considered clean if, after certified weed free, it does not touch soil or vegetative material, ie for a vehicle this means it travels on sealed or well-maintained unsealed roads.

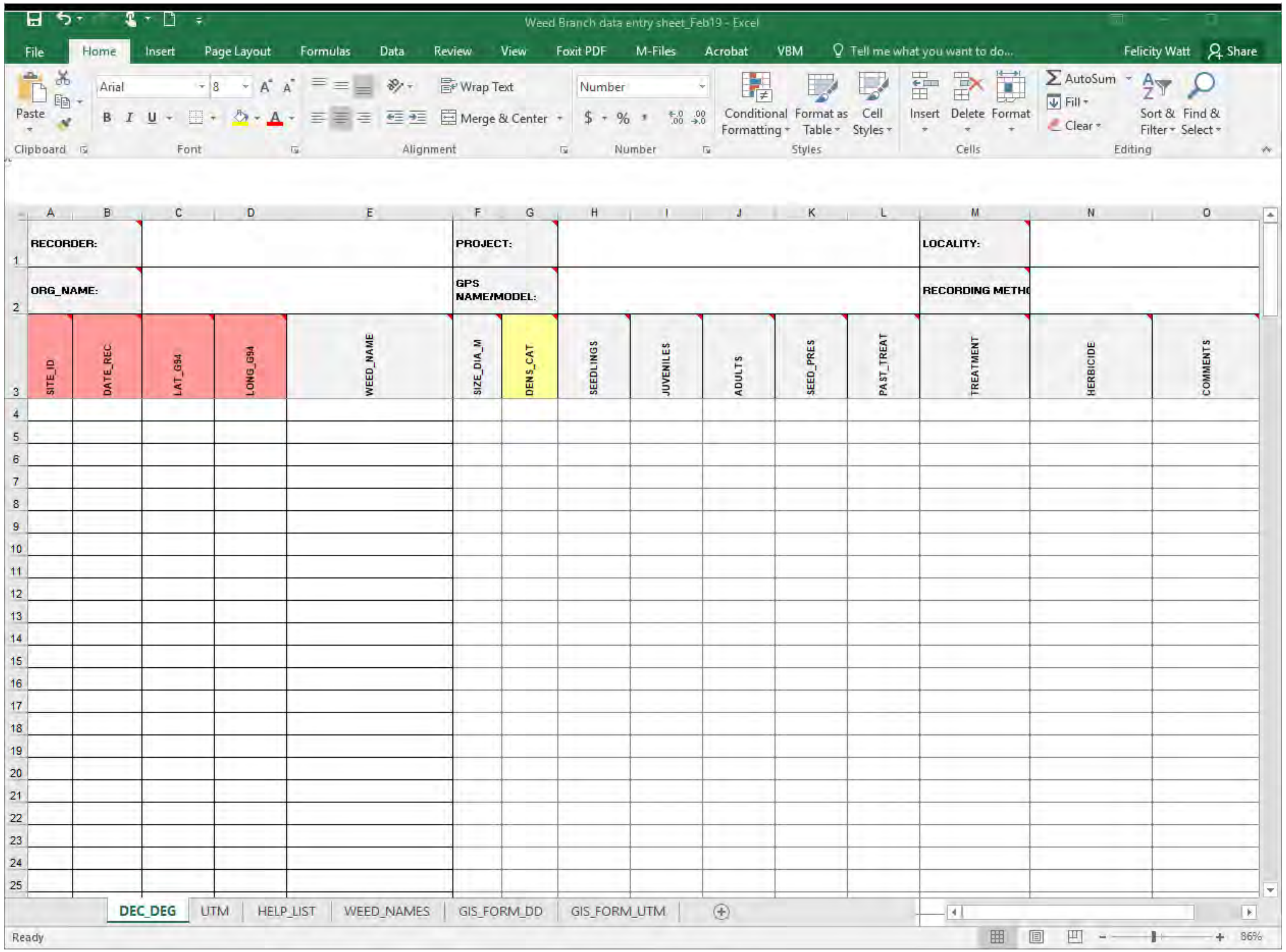
Equipment means anything other than a vehicle.

Vehicle includes anything used for carrying a thing or person by land, water or air.

Weed reproductive material means any part of a plant that is capable of producing another plant by sexual or asexual means. This includes seeds, bulbs, rhizomes, tuber, stem, leaf cuttings or a whole plant.

Well-maintained unsealed road means roads that do not have vegetation growing on or encroaching onto the area occupied by traffic.

APPENDIX C WEED CONTROL RECORDING TEMPLATE



EcOz Environmental Consultants

EcOz Pty Ltd.
ABN 81 143 989 039

Level 1, 70 Cavenagh St,
GPO Box 381,
Darwin, NT 0801

T: +61 8 8981 1100
E: ecoz@ecoz.com.au

www.ecoz.com.au

Santos

Appendix F: Aboriginal and Non-indigenous Archaeological Assessment

An Aboriginal and non-Indigenous archaeological assessment of proposed works in EP161, Northern Scope, McArthur Basin, Northern Territory

A report to Santos Ltd

by

Johan Kamminga
Allan Lance

Heritage Consulting Australia Pty Ltd
GPO Box 2677
Canberra ACT 2601

March 2019

Table of Contents

Executive summary

Heritage Consulting Australia Pty Ltd (HCA) has been engaged by Santos Ltd to undertake a cultural heritage (archaeological) survey and assessment of Aboriginal and non-Indigenous heritage for the Tanumbirini North and Inacumba North areas in Exploration Permit 161 (EP161) in the Northern Territory's McArthur Basin.

The area is to be subject to a further exploration program (the Northern Works Program) seeking to evaluate potential gas reserves that were identified during exploration first conducted in 2013 with subsequent seismic survey and drilling undertaken. In the earlier seismic study, 500km of 2D seismic data were acquired to map the regional sub-surface geology and an exploration well (Tanumbirini 1) was drilled in June 2014.

The area under investigation is part of the Exploration Permit Area 161, situated 350 km south-east of Katherine. The location where the next phase of exploration is to occur is near the previously drilled Tanumbirini well, located 12 km north of the Carpentaria Highway (Highway 1) and approximately 135 km east of the township of Daly Waters at the junction of the Stuart Highway and Highway 1.

The further work program will entail a 2D seismic survey along a 10 km transect through the Tanumbirini North area, a drilling program (initially one horizontal well) in the same area, and a drilling program (initially one vertical and one horizontal well) in the Inacumba North area. There will be additional activities associated with this program including upgrading of access tracks to facilitate the entry and egress of vehicles during the seismic survey program. The Inacumba North area is situated ~15 km east of the Tanumbirini North location. At both locations where drilling is to occur there will be impacts within an area of approximately 200 m of the hole centre to accommodate drilling infrastructure, in addition to upgrades to access tracks and safe access to the Carpentaria Highway.

An archaeological field assessment was carried out by archaeologist Dr Johan Kamminga over 3 days in early March 2019, adopting a methodology consistent with the Northern Territory Cultural Heritage Act, 2011. The proposed seismic survey line route, locations of proposed upgrades to existing roads and tracks, well locations and the general project area were intensively examined for traces of prior Aboriginal habitation and resource use, and non-Indigenous settlement, to allow the development of appropriate management strategies to ensure the protection of the region's cultural heritage values.

This archaeological study did not address places of contemporary Indigenous significance, as defined by the *Northern Territory Aboriginal Sacred Sites Act,* 1989. The relevant statutory body for the project area is the Northern Land Council which has previously carried out an assessment in the project area and its vicinity. Two recorded sites of special Aboriginal significance were identified during this Sacred Site assessment and these sites have been protected from any potential impacts by broad exclusion zones. These Sacred Sites were not visited during the present study, nor were the exclusion zones entered.

Site register search and archaeological sensitivity modelling

Prior to the field inspection of the project area, a review of previously located sites, as recorded in the Northern Territory Heritage Register, was undertaken. The mapping of these sites and the development of models of Aboriginal site distribution that this permits, revealed the most archaeologically sensitive zones throughout the project area. This modelling assisted with the formulation of a field survey strategy to identify locations most likely to contain evidence of prior Aboriginal activity and cover any areas that may experience ground disturbance during the planned exploration and drilling program.

No Aboriginal, Macassan or non-Aboriginal archaeological places, sites or relics had previously been recorded within the project area. The closest registered Aboriginal archaeological sites or relics are at least 7 km distant from the project area. These are mostly isolated stone artefacts or stone artefact scatters. There are, however, restricted Aboriginal rock art sites 18km from the project area. These are found in rocky escarpments, a landform that does not occur in the area where construction activities are to occur.

Field investigation

The archaeological survey and assessment focused on the identification of Aboriginal, Macassan and other non-Aboriginal archaeological places, sites and relics as defined by the *Northern Territory Heritage Act,* 2011.

The field survey covered all environmental zones within the project area. The areas that were investigated included the 10km long route of a proposed seismic line that traversed the Tanumbirini North project area; areas around the proposed Inacumba pilot well location, and around existing infrastructure including roads and well leases; and a number of other locations in and around the project area. The site inspection assisted with an understanding of the distribution of items of Aboriginal cultural heritage significance in this landscape.

Results

This archaeological field survey carried out as a core component of the archaeological assessment revealed no Aboriginal relics or sites (for example stone tools, former camp sites, or culturally modified trees), nor any non-Aboriginal relics or sites. This indicates that Aboriginal sites and relics are relatively sparse to very sparse within the more general area of northern Tanumbirini Station.

There is no indication that any Aboriginal archaeological or historical sites/relics will be encountered or impacted by proposed activities in this portion of EP161.

Conclusions

The results of this archaeological study indicated that there are no identifiable archaeological heritage constraints on proposed work activities in the project area. This includes any activities in the vicinity of the existing gas and water well, the proposed seismic line, the proposed Inacumba pilot well, and the proposed widening or other modification to access tracks, or turning areas along the Carpentaria Highway.

In the unlikely event that previously undetected items of Aboriginal or non-Indigenous cultural heritage are encountered in the project area during planned exploration or construction activities, these should be noted, assessed, recorded and avoided. If avoidance is impracticable, a further assessment should be undertaken to evaluate cultural heritage significance, and in consultation with the Heritage Branch of the Northern Territory Department of Tourism, Sport and Culture, decide on the most appropriate remediation measures.

1. Introduction

Heritage Consulting Australia Pty Ltd (HCA) has been engaged by Santos Ltd to undertake a cultural heritage (archaeological) survey and assessment of Aboriginal and non-Indigenous heritage for the Tanumbirini North and Inacumba North areas in Exploration Permit 161 (EP161) in the Northern Territory's McArthur Basin.

The area is to be subject to a further exploration program (the Northern Works Program) seeking to evaluate potential gas reserves that were identified during exploration first conducted in 2013 with subsequent seismic survey and drilling undertaken. In the earlier seismic study, 500 km of 2D seismic data were acquired to map the regional sub-surface geology and an exploration well (Tanumbirini 1) was drilled in June 2014.

The area under investigation is part of the Exploration Permit Area 161, situated 350 km southeast of Katherine. The location where the next phase of exploration is to occur is near the previously drilled Tanumbirini well, located 12 km north of the Carpentaria Highway (Highway 1) and approximately 135 km east of the township of Daly Waters at the junction of the Stuart Highway and Highway 1. The location of the proposed works is shown in Figure 1.

The further work program will entail a 2D seismic survey along a 10 km transect through the Tanumbirini North area, a drilling program (initially one horizontal well) in the same area, and a drilling program (initially one vertical and one horizontal well) in the Inacumba North area. There will be additional activities associated with this program including upgrading of access tracks to facilitate the entry and egress of vehicles during the seismic survey program. The Inacumba North area is situated ~15 km east of the Tanumbirini North location. At both locations where drilling is to occur there will be impacts within an area of approximately 200 m of the hole centre to accommodate drilling infrastructure, in addition to upgrades to access tracks and safe access to the Carpentaria Highway.

An archaeological field assessment was carried out by archaeologist Dr Johan Kamminga over 3 days in early March 2019, adopting a methodology consistent with the Northern Territory *Cultural Heritage Act*, 2011. The proposed seismic survey line route, locations of proposed upgrades to existing roads and tracks, well locations and the general project area were intensively examined for traces of prior Aboriginal habitation and resource use, and non-Indigenous settlement, to allow the development of appropriate management strategies to ensure the protection of the region's cultural heritage values.

This archaeological study did not address places of contemporary Indigenous significance, as defined by the *Northern Territory Aboriginal Sacred Sites Act,* 1989. The relevant statutory body for the project area is the Northern Land Council which has previously carried out an assessment in the project area and its vicinity. Two recorded sites of special Aboriginal significance were identified during this Sacred Site assessment and these sites have been protected from any potential impacts by broad exclusion zones. These Sacred Sites were not visited during the

Figure 1. Location of the project area.

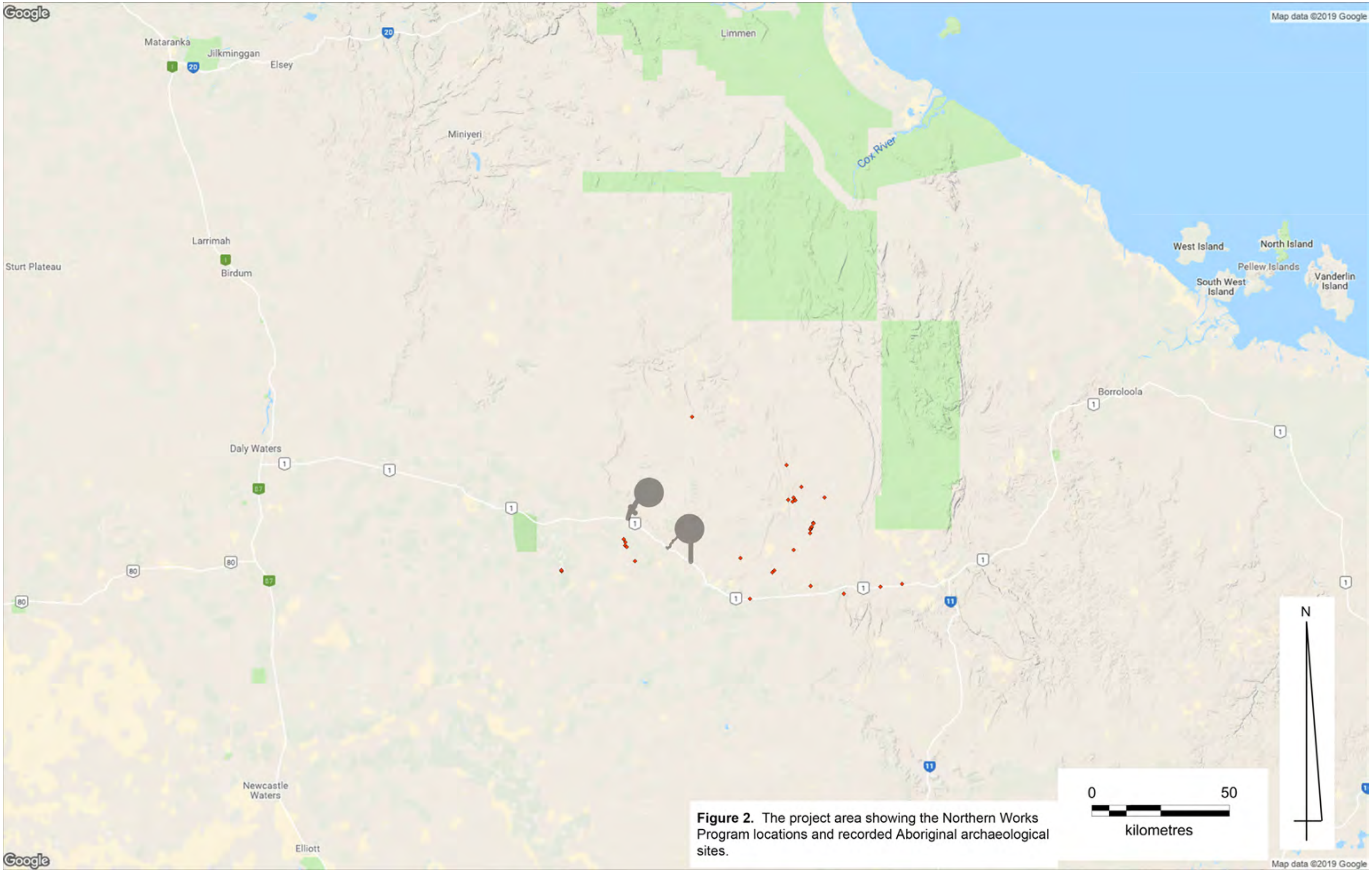


Figure 2. The project area showing the Northern Works Program locations and recorded Aboriginal archaeological sites.

present study, nor were the exclusion zones entered.

2. The project area

The project area lies within Santos exploration lease EP161, located on Tanumbirini Station, a 5,000 km^2 beef cattle grazing property located 420 km southeast of Katherine in the McArthur Basin, situated in the north-east of the Northern Territory. The project area is located within Barkly Shire and in NT Cadastral Parcel 701 of Arnold. The closest towns are Daly Waters (approximately 135 km to the west) and Borroloola (approximately 165 km to the east).

Cattle grazing is the primary activity on Tanumbirini Station, with some minor cropping around the station homestead. In the 1960s, pastoral activity was restricted to the northern, northeastern, and extreme western parts of the station, the remaining area being vegetated by scattered dense patches of lancewood (*Acacia shirleyi*) and “poor grass” (Paine 1963:1).

Tanumbirini Station Homestead settlement (the only permanent dwellings on the property) and the Santos project areas are accessed from the Carpentaria Highway, an all-weather public road constructed in 1959.

3. Environmental setting

3.1 Topography

The topography of the project area comprises gently undulating plain, moderately graded slopes in the order of 0-2°, and ephemeral drainage features such has creek channels and washouts (Santos 2013). The elevation of the Santos project area within the station ranges from 200 to about 260 m asl.

3.2 Land systems

The Northern Works Program areas (Tanumbirini North and Inacumba North) are located at the boundary of the Gulf Falls and Uplands Bioregion and Sturt Bioregions (Figure 3). A detailed investigation of the regional ecosystems has been prepared for the Bullwaddy Conservation Area, situated 33 km to the west and appropriate descriptions have been derived from the Conservation Area Management Plan (NT Parks and Wildlife Commission 2005) and earlier CSIRO investigations of regional Land Systems (Christian *et al.* 1954 and Perry 1960; Perry 1963).

The region is characterised by flat erosional plains dominated by savannah woodlands with mixed eucalypt species, overlying an understory of mixed grasses, with open woodlands on the clay floodplains (NT Parks and Wildlife Commission 2005:5). There are pockets of acacia woodland through this region, including the lancewood (*Acacia shirleyi*) found in the Bullwaddy Conservation Area.

3.3 Geology

The project area contains bedrock formations of Upper Proterozoic, Lower Cambrian, and Lower Cretaceous age, and forms a tableland, which is part of the extensive Barkly-Beetaloo Tableland (Dunn, Smith and Roberts 1962). The low-relief plain is present throughout the project area and

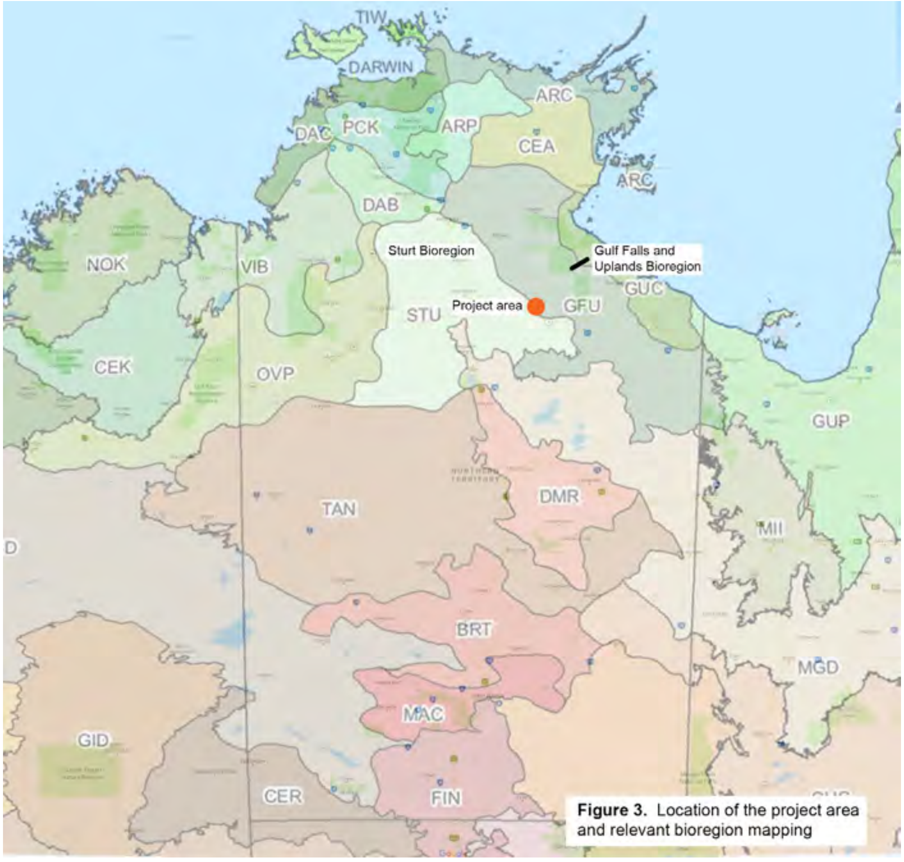


Figure 3. Location of the project area and relevant bioregion mapping

is bounded on the north by a well-defined scarp about 60 m high (Figure 4). The surface of the tableland, which lies between 230 and 274 m asl, is gently undulating and represents parts of an extensive laterite land surface which extends across the entirety of Tanumbirini Station (Paine 1963:3).

The project area is located within the 'Mature Gulf Fall area' (Paine 1963: Fig. 1), where the exposed Upper Proterozoic rocks have altered a drainage system inherited from an early Tertiary laterite surface. Relief in this area is generally 30 to 46 m and locally 76 m. Lower Cretaceous rocks abut the ranges of Upper Proterozoic rocks. Tanumbirini Creek, in the vicinity of the homestead, has been superimposed on Upper Proterozoic rocks, flowing north east across two major sandstone strike ridges of Roper Group rocks (Paine 1963:4).

The Upper Proterozoic rocks up to 5,500 m thick (Paine 1963:12), which outcrop only in the north eastern part of Tanumbirini Station, belong to a sequence laid down in the McArthur Basin, which extended from Arnhem Land to the Queensland border. The sequence is divided into Tawallah, McArthur, and Roper Groups. The Tawallah and Roper Groups are represented in the Tanumbirini Station area (Paine 1963:5).

A small outcrop of altered dolerite/basalt of the Settlement Creek Volcanics overlies glauconitic sandstone of the Rosie Creek Formation at Eight Mile Creek to the northeast of the project area (Paine 1963:5).

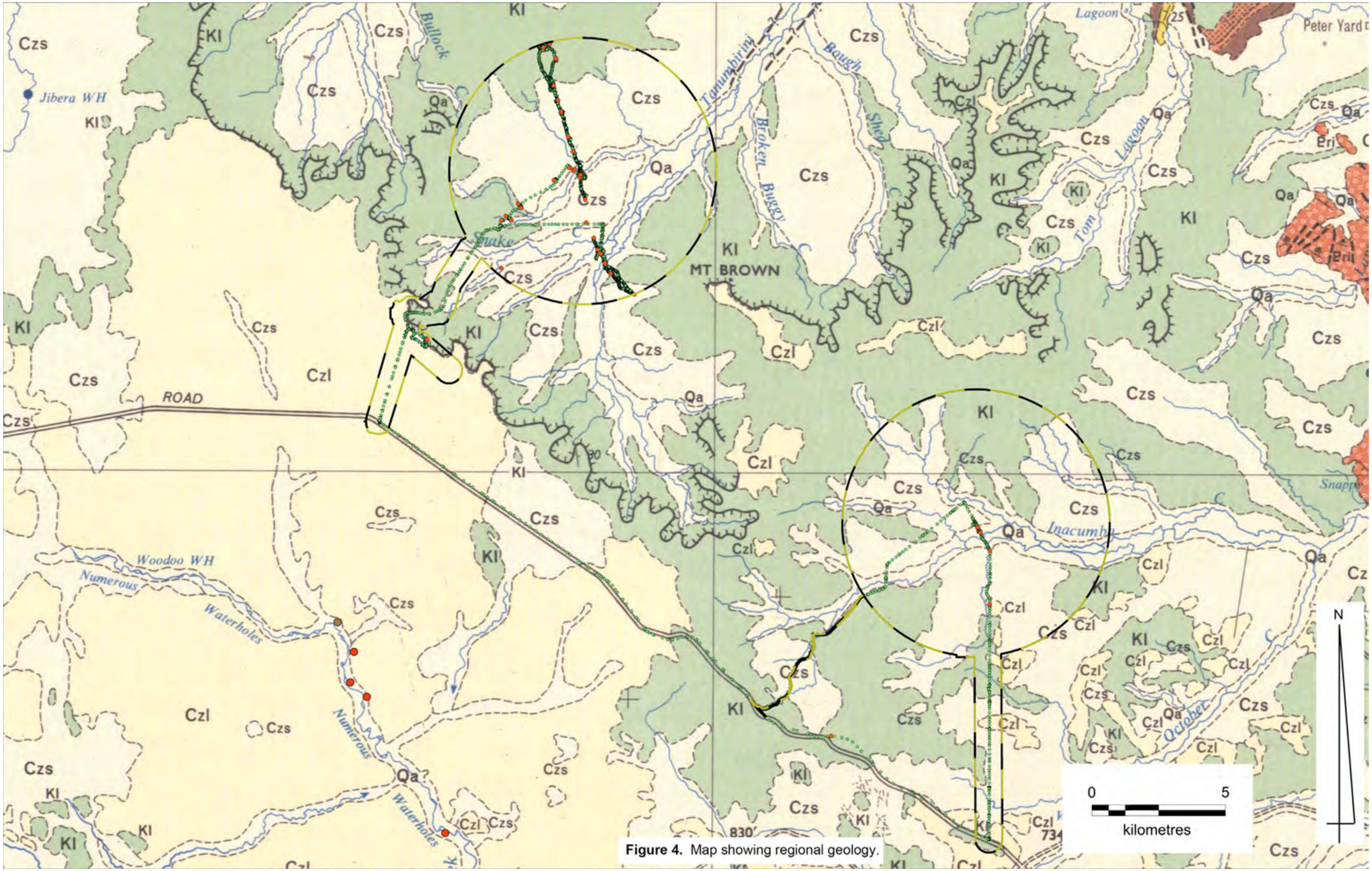


Figure 4. Map showing regional geology.

A layer of unlateritized, partly lithified white leached claystone that exhibits sub-conchoidal fracture outcrops in a road cutting of the Carpentaria Highway in the proposed road modification area at the T-intersection of the Inacumba North Area and also along the southernmost portion of the access track to the Inacumba North Area (see Paine 1963:9).

3.4 Hydrology

A watershed dividing inland from seaward drainage systems extends across the property from northwest to southeast. This watershed is of very low relief and the inland drainage system is poorly developed (Paine 1963: 1). The catchment within the project area drains north-easterly towards the Gulf of Carpentaria.

Watercourses flow at intervals after rain during the wet season but are dry for the remainder of the year. Scattered waterholes may survive the dry season and, other than modern bores with reservoirs, are the only source of water for stock throughout the station during the dry season.

More specifically, water flow in Tanumbirini Creek and Inacumba Creek and in their very minor tributary and overflow drainage lines within the general project area occurs during the wet season, predominantly due to cyclones and monsoonal rainfall. The creeks and their tributary drainage lines are largely ephemeral and usually run dry during the dry season. The flow is of short duration and characterised by high turbidity causing undercutting and creation of creek channel banks especially on bends.

3.5 Vegetation

In general, vegetation types include woodland, open woodland, open forest, tussock grassland and hummock grassland. The dominant species within the vegetation communities present include Darwin stringybark (*Eucalyptus tetrodonta*) and variable-barked bloodwood (*Corymbia dichromophloia*) with a spinifex understorey, and woodland dominated by Kullingal (*Eucalyptus pruinose*) or *Melaleuca* spp. with tussock grass understorey. There are also areas of Lancewood (*Acacia shirleyi*) thicket, Bullwaddy (*Macropteranthes keckwickii*) woodland and Acacia scrub (Santos 2013:5).

Within a radius of ten kilometres of the project area the vegetation types are woodland open forest and tussock grassland. The dominant vegetation type in the immediate area of the Tanumbirini North and Inacumba North project area is woodland, and along the Carpentaria Highway junction for Inacumba North it is woodland and open forest (Santos 2016). The species within the woodland vegetation communities present are dominated by Kullingal and variable barked bloodwood with *Melaleuca* spp. and tussock grass understorey.

3.6 Fauna

Food resources available to Aboriginal people in the past would have been varied and would have included birds, marsupials, reptiles and insects, and plant parts and honey. (see Mulvaney and Kamminga 1999:79-88).

The wider McArthur Basin region supports a diverse range of fauna. Over 435 vertebrate species have been recorded from the Gulf Falls and Uplands bioregion. The sandstone ranges and stony hills of the region support a range of marsupials, reptiles, fish and birds, including a number of endemic species, including Carpentarian Rock Gecko (*Gehyra Borroloola*), Hosmer's Skink (*Egernia hosmeri*) and the Carpentarian Grass-wren (*Amytornis dorotheae*). Major river systems are important environments for many species because of the much lower annual rainfall than the more northern savannas, and the very high summer temperatures.

In the project area itself, the range of plants and animals would have been more restricted, with the dominant fauna being reptiles and when local rainfall permitted, grazing macropods and birds. Spectacled hare-wallabies (*Lagorchestes conspicillatus leichardtii*) find refuge in vine thickets and are common (NT Parks and Wildlife Commission of the Northern Territory 2005:10).

3.7 Climate

The region experiences a 'grassland' climate, based on the Köppen classification system. This classification consists of two distinct seasons: the wet season which lasts from December to March; and the generally dry conditions which last for the remainder of the year (winter drought).

Mean maximum temperature ranges from 29.7°C in June to 38.6°C in November and historically the highest temperatures recorded have been in November. The mean minimum temperature ranges from 12.2°C in July to 24.9°C in December-January. Coolest temperatures occur in June-July. At Daly Waters the average annual rainfall total is 660 mm.

The highly seasonal rainfall and absence of reliable waterholes in the minor creeks that cross the project area may have discouraged sustained occupation of the region by Aboriginal people during the dry season.

3.8 Soils

The landscape of northern and central Australia is ancient and highly weathered. Soil types are susceptible to erosion given that the region experiences long dry periods followed by intense rainfall. In this environment, the soils become disturbed and once disturbed are highly erodible. Termite and other invertebrate bioturbation also reduce and even eliminate the original stratigraphic integrity of biomantle loose sediments.

The project area is characterised by plains and rises associated with deeply weathered soil profiles (laterite) including sand sheets, sandy and earth soils, in particular lateritic yellow earths and brown clays.

In general, the soils in the project area are mostly shallow and gravelly, often overlaying discontinuous layers of detrital ferruginous gravel (commonly termed ironstone), derived from the weathering of haematitic laterite, preserved as iron-rich rock layers in the Sturt Plateau bioregion south of the Carpentaria Highway, along with locally exposed claystone bedrock. This detrital ironstone is ubiquitous and at times extremely abundant on ground surfaces throughout the project area (see Paine 1963:10).

The soils are Quaternary and Holocene in age and are dominated by kandosols and rudosols. Kandosols are massive and earthy soils (formerly red, yellow and brown earths) that are widespread across the Sturt plateau to the south. More specifically this soil type is a Ferric brown kandosol that has well-developed B2 horizon in which the major part is massive or has only a weak grade of structure (for descriptive classification see Isbell 1993). Rudosols are very shallow soils or those with minimal soil development and include very shallow gravely soils. In particular, this soil in the project area is a gravelly leptic rudosol originating from lateritic lithosols (Tasker 2017).

Brown demosol also occurs in the project area (Tasker 2017) and these originate from locally occurring lateritic yellow earths/brown clays. This is a clayey soil with a strong blocky structure and no clear or abrupt textural changes between horizons and tends to have a B2 horizon with structure more developed than weak.

Surficial Quaternary alluvium occurs along watercourse corridors and washouts and in other areas of watercourse catchments (Figure 4).

4. Aboriginal history and settlement in the region

4.1 Local Aboriginal organisation

In his historical reconstruction of pre-contact Aboriginal Australia, Tindale (1974) identified the tribal affiliation of the area as *Jingulu*. Tindale defined ‘tribal’ groups on the basis of written accounts of variable quality; however, many of these records were unreliable. Tindale’s tribal boundaries were largely defined according to what he understood to be language groups and his work was conceptualised according to a model of band social organisation in which the clan or ‘horde’ was considered to be the group which possessed political power and proprietary rights to land.

The assumptions inherent in this conflation of language group with the concept of a ‘tribe’ are no longer regarded by anthropologists as appropriate. Similarly, the concept of ‘tribe’ as a territorial group is debatable. In Aboriginal society, people were invariably multilingual rather than monolingual and representing language groups as bounded social groupings is now thought to be inappropriate. In the Radcliffe-Brown model, the land/language relationship was seen as indirect: the estate of a tribe was defined as the aggregation of all the clan estates who shared a common language. This relationship is now viewed to be direct – it is recognised that the importance of land/language relations in Aboriginal society is that particular languages and particular tracts of country were directly linked according to Dreaming events and activity.

While it was previously assumed that tribes or language groups functioned as politically cohesive corporate groups, it is now recognised by anthropologists that linguistic groupings do not structure the Aboriginal social and geographical landscape. Sutton and Rigsby (1979:722) argue that Tindale’s tribal boundaries are not meaningful at either a demographic or political level. In order to overcome Tindale’s limited and flawed tribal boundary model, recourse must be made to more contemporary anthropological concepts and understanding.

Drawing on accounts of a number of early ethnographers, Wesson (2000) has defined the multi-dimensional aspect of Aboriginal social geography based on habitual place of residence, dominant mode of livelihood, and language. This approach is more meaningful that those underpinning earlier anthropological models.

4.2 Tribal groups in the area

Tanumbirini Station is located within the territory of two language or tribal groups, Jingili and Alawa speakers (Tindale 1974; Sharpe 1969). The Jingili language was spoken by people who inhabited the area including Hodgson Downs, Nutwood Downs, and Tanumbirini stations, south of the Roper River and east of the Stuart Highway (Sharpe 1969).

The Jingulu language is classified as belonging to the Mirndi family of non Pama-Nyungan languages. An early word-list was compiled by F.A. Gillen (Pensalfini 2004:143). Following in the wake of pioneering work by Neil Chadwick in the 1970s, Robert Pensalfini wrote a grammar of Jingulu on the basis of fieldwork with its last known fluent speakers (Pensalfini 1997).

According to Jingulu oral tradition, the Jingili originally migrated from the Great Western Desert (Tindale 1974:236). Tindale estimated the size of Jingili territory to be approximately 15,00 km^2, with the southern frontier around Renner Springs extending northwards to Newcastle Waters and also taking in the area of the Ashburton Range. To the east the territory encompassed Cattle Creek south to Wave Hill and Ucharonidge. Their western extension of their territory approached Lake Woods (Tindale 1974:236).

There has been very little academic study of the Alawa language or people (also known as Galawa or Waliburu). The most recent work was a study of the language by Sharpe nearly 50 years ago (Sharpe 1969).

In the early 1960s, Tanumbirini Station was inhabited by a single station manager and several Aboriginal people who lived and worked on the station with a number of their family members. The language or tribal affiliation of these residents was not reported.

5. Nature of the proposed work activities

There are a number of activities proposed as part of Santos Northern Works Program in EP161. The locations where the impacts will occur are shown in Figure 6. Proposed activities will include a 2D seismic survey along a 10 km transect through the Tanumbirini North area. There will be additional activities associated with this seismic survey program including upgrading of access tracks to facilitate the entry and egress of vehicles.

Impacts from the seismic survey will be minimal. It will be necessary for vehicle access along the 10 km line, which may require some clearing of uneven ground and to allow crossing of minor watercourses. The line will then be prepared and geophone arrays laid by hand with access provided by four wheel drive vehicles. Once the geophone lines have been laid, the seismic survey will be conducted using vibroseis trucks shod with pneumatic tyres. The impacts from this activity will be localised and shallow and will mainly arise when access for the seismic line is prepared. Once the seismic survey program has been completed the vehicle tracks should, over time, revert to their pre-survey state.

The second area where works are planned is situated 15 km further to the east, in the Inacumba North area. Here a pilot well is to be drilled, requiring impacts within an area of approximately 200 m of the hole centre to accommodate drilling infrastructure, in addition to upgrades to access tracks and modifications of access onto the Carpentaria Highway, to permit safe entry and egress for trucks.

Construction activities for the well will require ground works that will include:

- Site preparation for a well pad,
- New access roads and upgraded access roads,
- Site preparation for a temporary camp including temporary sewerage treatment plant,
- Site preparation of laydown areas,
- Construction of borrow pits,
- Construction and equipping of water bores,
- Dedicated area for equipment storage,
- Installation of temporary fencing, gates and motor grids.

6. Aboriginal cultural heritage assessment methodology

Ideally, there are five major steps that are required in archaeological heritage assessment.

Step 1 – Register search

A search of relevant heritage registers and databases is undertaken to:

- ascertain if any known Aboriginal or non-Aboriginal heritage sites/relics occur within or in close proximity to the project area;
- provide data to assist in predicting the types and frequency of Aboriginal and non-Aboriginal sites/relics that may occur in the development area, within the local area or region generally.

Step 2 – Assessment of landscape features and sediments

The second stage of the assessment process requires the examination of the landscape setting and environment of the project area. These include an understanding of the surface geology, geomorphology and sediments, which may have affected past land-use practices, survival of sites in the landscape and the detectability of sites. This assessment also includes noting of tree varieties and tree ages to assist in identifying culturally modified trees. In particular, certain landscape features have a higher potential to contain Aboriginal relics.

Step 3 – Desktop assessment and visual inspection

An archaeologist identifies landscape features with the potential to contain sites and undisturbed relics. Relevant archaeological research reports for sites within the project area and for the

area or region generally, as appropriate, are examined to provide baseline data and a broader understanding of the cultural heritage context of the area subject to potential impact.
A field assessment entails a pedestrian archaeological survey of the subject land, with particular attention to archaeologically sensitive landscape features such as watercourses, rocky escarpments, areas of exposure, and pavements with exposed gravel on which stone artefact scatters are readily detectable.

Step 4 – Reporting results
Reporting of the findings and recommendations from the assessment. A written report documenting the procedures, results and recommendations of the archaeological heritage assessment is produced to support the conclusions.

Step 5 – Further investigation and impact assessment (if required)
After assessing the significance of the archaeological site/relic, recommendations are made regarding compliance with the provisions of the Northern Territory *Heritage Act,* 2011*.*

The specific aims of this archaeological assessment were to:

1. Identify known Aboriginal and non-Aboriginal archaeological heritage sites and/or relics within the subject land area and assess the area for its potential to contain unidentified sites/ objects.

2. Identify any potential archaeological heritage constraints and formulate recommendations and management strategies and options with regard to the proposed activity/development.

3. Provide an assessment as to whether or not further archaeological heritage investigation or assessment is required prior to the commencement of the proposed development.

4. Determine whether further detailed investigations may be needed to be undertaken to meet statutory requirements.

7. Results of the background research and the Site Register searches

Searches of the NT Heritage Register, Aboriginal Areas Protection Authority (AAPA) database, and NT Archaeological Sites Database were undertaken on 4 March 2019. (Table 1, and Figure 5).

Other documents reviewed included the relevant work program issued to Northern Lands Council (NLC), an update to that work program, geospatial data and maps of the project area derived from the database searches, archaeological, historical and anthropological literature, and scientific literature relating to environment and geology.

Archaeological research over the past five decades has shown that Aboriginal people have occupied Australia for at least 40,000+ years (Mulvaney and Kamminga 1999:2). By 35,000 years

Site_Name	Zone	East GDA94	North GDA94	Site_Type	Contents
Broadmere St. 1				rock art	paintings
Balbirini Creek 6	53			Stone artefact scatter, grindstone portable	artefact scatter
Balbirini Creek1	53			Stone artefact scatter	artefact scatter
Balbirini Creek2	53			Stone artefact scatter	artefact scatter
Balbirini Creek3	53			Stone artefact scatter	knapping floo
Balbirini Creek4	53			quarry	quarry
Balbirini Creek5	53			Stone artefact scatter, grindstone portable	artefact scatter
Bauhinia Downs1	53			Stone artefact scatter	artefact scatter
Binda	53			Rock art, Restricted anthropological site, ceremonial ground	petroglyph
Broadmere St. 10	53			Stone artefact scatter	artefact scatter
Broadmere St. 11	53			rock art	paintings
Broadmere St. 3	53			Stone artefact scatter, midden	artefact scatter, midden
Broadmere St. 4	53			Stone artefact scatter, quarry	artefact scatter, quarry
Broadmere St. 5	53			Stone artefact scatter	artefact scatter
Broadmere St. 7	53			Stone artefact scatter, midden	artefact scatter, midden
Broadmere St. 8	53			rock art	paintings
Broadmere St. 9	53			rock art	paintings
Carpenteria Hwy 1	53			Stone artefact scatter, grindstone portable	artefact scatter
Eleanor Pool Yard1	53			stone artefact scatter, historic site, stone arrangement, grindstone portable	artefact scatter, stone arrangement , faunal remains
Favenc Site (Telecom)	53			Stone artefact scatter	artefact scatter
Goanna Site (Telecom) [Pipeline Site B - Mitchell: not located]	53			Stone artefact scatter	artefact scatter
Lansen Springs (Broadmere St. 6)	53			Stone artefact scatter	artefact scatter
Newcastle Creek 1	53			Isolated stone artefact	stone artefact
Newcastle Creek 2	53			Stone artefact scatter	artefact scatter
Newcastle Creek 3	53			Stone artefact scatter	artefact scatter
Newcastle Creek 4	53			Stone artefact scatter	artefact scatter
Newcastle Creek 5	53			Stone artefact scatter	artefact scatter
Old Tanumbirini Station	53			Skeletal remains, stone arrangement	skeletal remains, stone arrangement
OT Down2	53			Stone artefact scatter	artefact scatter
OT Down3	53			Stone artefact scatter, grindstone portable	artefact scatter
OT Downs1	53			quarry	quarry

Table 1. List of sites recorded on the Northern Territory Heritage Register for the region around the project area. Old AGD66 coordinates have been converted into GDA94 format.

Pipeline Site A - Go-anna Creek 2	53			rockshelter deposit, rock art, stone artefact scatter, shell scatter, grindstone portable	artefact scatter, paintings, midden
Pipeline Site C - Little Creek 2	53			Stone artefact scatter	artefact scatter
Urrwalala [DML - 1975, MH - 1986]	53			Stone artefact scatter, shell midden, rock art, grinding place non-portable	artefact scatter, midden, paintings, grinding hollows / grooves
Yaroo 1	53			Stone artefact scatter	artefact scatter
Yaroo 2	53			Stone artefact scatter	artefact scatter
McArthur River 2D Seismic Site 1	53			Stone artefact scatter, hearths, camp sites, knapping floor	Stone artefact scatter

Table 1. List of sites recorded on the Northern Territory Heritage Register for the region around the project area. Old AGD66 coordinates have been converted into GDA94 format.

ago all major environmental zones in Australia, including semi-desert and desert country and even periglacial environments of Tasmania, were occupied (Mulvaney and Kamminga 1999:114).

At the time of early Aboriginal occupation, Australia experienced moderate temperatures. At the commencement of the Last Glacial Maximum (LGM) at about 24-22,000 years ago, sea levels fell to about 130 m below present levels and accordingly, the continent was correspondingly larger. However, between 24,000 and 12,000 years ago (at the height of the Last Glacial Maximum) dry and either intensely hot or cold temperatures prevailed over the continent.

With the amelioration of glacial conditions, temperatures rose with a concomitant rise in sea levels. By ca. 6000 BP sea levels had more or less stabilised at their current position (but now again rising slowly). With the changes in climate during the Holocene, Aboriginal inhabitants had to deal not only with reduced landmass but with changing hydrological systems and vegetation; forests and woodlands again spread across the grasslands and shrublands of the Late Glacial Maximum.

Human occupation of the study area must have been very sparse throughout prehistory into modern times, especially so for earlier millennia. The area was environmentally challenging, only becoming more habitable during the later Holocene period.

Only one major archaeological consultancy report is available for the wider region generally (Guse and Collis 1998). This survey and assessment report was prepared for North Australian Basins Resource Evaluations, AGSO. The study was along a proposed 70+ km 2D seismic line in the McArthur River Region, well to the east of the project area. The topographic, geological and environmental contexts do not correspond sufficiently to those of the current archaeological survey areas to provide more than the most general information. For instance, there are rock shelters habitation sites, rock art sites and rock shelters with burials in the MacArthur River region. The land systems in which these sites occur are not present in the vicinity of the current survey

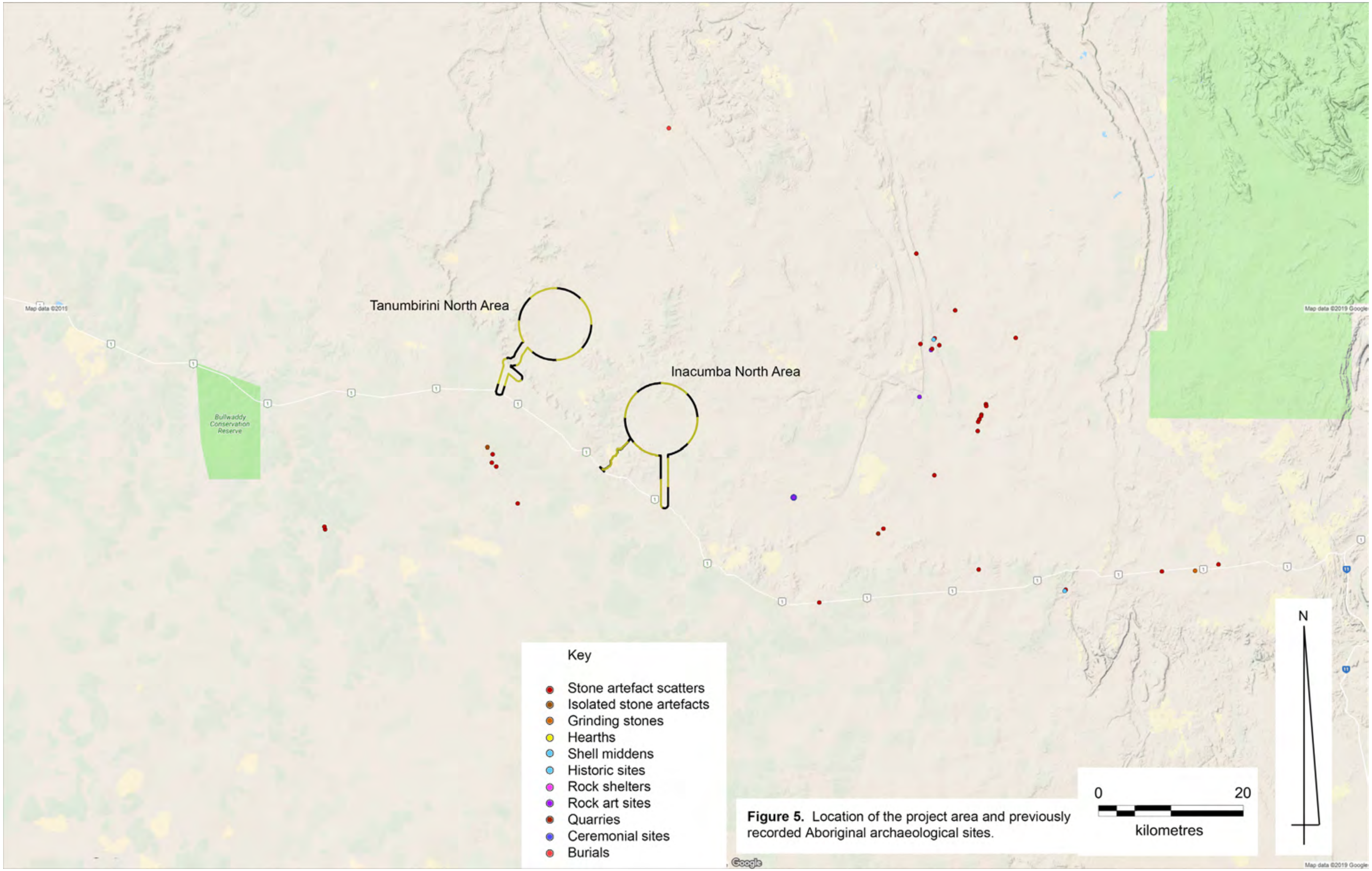


Figure 5. Location of the project area and previously recorded Aboriginal archaeological sites.

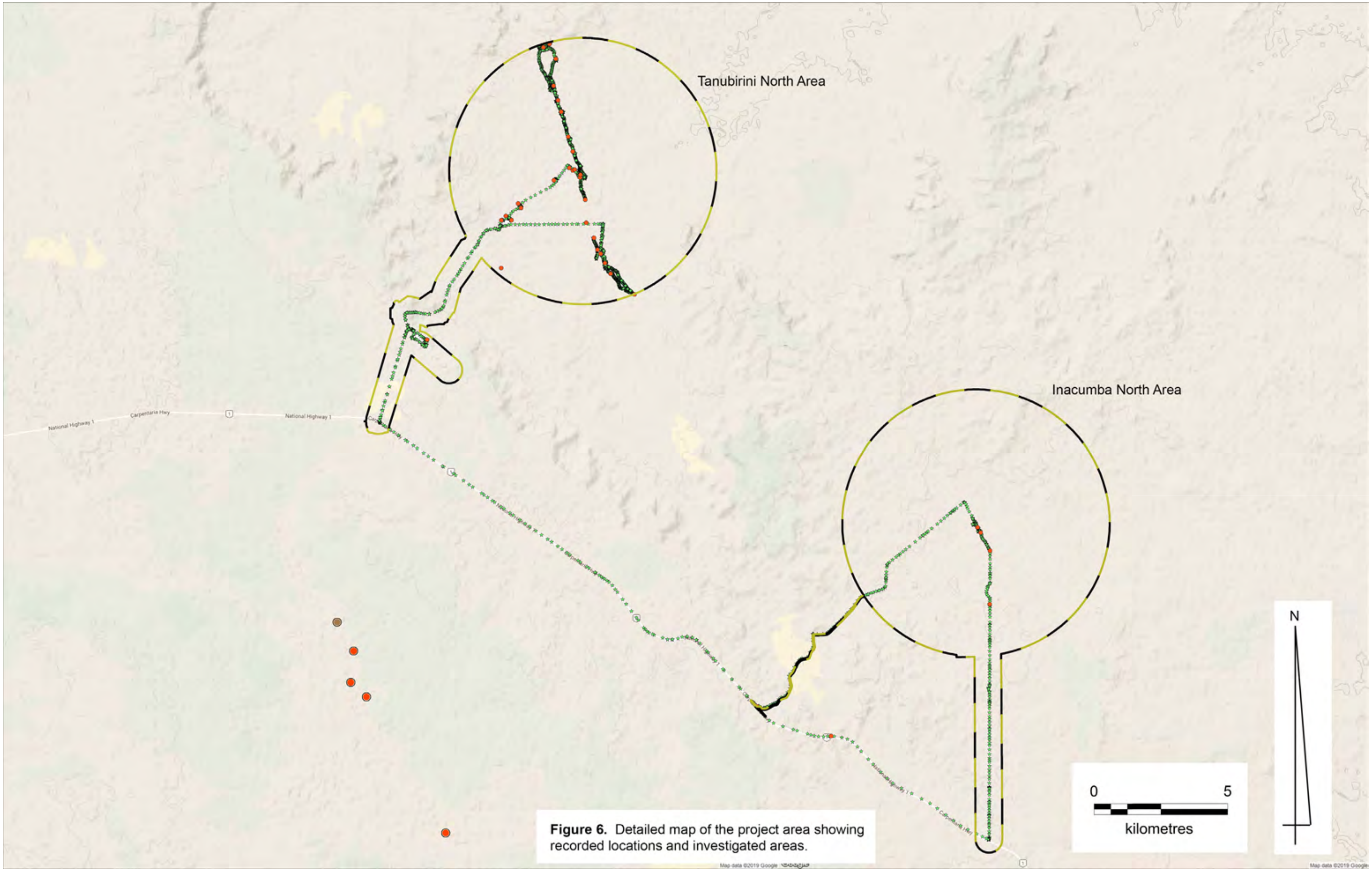


Figure 6. Detailed map of the project area showing recorded locations and investigated areas.

areas because of an absence of bedrock suitable for shelter or cave development.

Closer to the project area, small archaeological surveys have been undertaken in previous decades for various developments such as telecommunications infrastructure. Within this more proximal general area but still well beyond the current archaeological survey areas, stone artefact scatters (mostly flaking débitage) are the predominant site type, followed by a single hearth and skeletal remains, two stone arrangements, three shell middens, six rock art sites and two postulated 'quarry' sites.

The closest archaeological sites are approximately seven kilometres south of the Carpentaria Highway, and at least 15 km from the nearest significant construction or seismic survey impacts. This cluster of four stone artefact scatters and one isolated stone artefact are found beside waterholes in Newcastle Creek, a southward flowing stream. A rock art site is found approximately 16 km southeast of the Inacumba North Area. This site is found in a rocky escarpment near the headwaters of Parsons Creek. Further sites (quarries, stone artefact scatters and hearths) are found in the escarpments to the east of these sites and more than 30 km from the project area.

7.1 Historical places

A search of the NT Heritage Register has indicated that there are no listed heritage items or places in the vicinity of the project footprint. (Santos 2018:53). Only two declared historical places have been registered in the region NRETAS (2010). Both of these places are south of the village of Elliot and more than 150 km from the project area (NRETAS 2010).

Ucharonidge Station is located 19 kilometres south of Elliott and 77 kilometres east on the Barkly Stock Route on the Barkly Tableland. Powell Creek Overland Telegraph Station, south of the village of Elliott and over 170 km distant from the proposed project area. This site was listed on the Register of the National Estate and declared a Heritage Place under provision of the *Heritage Act*. The station was established in 1872 and is one of 11 repeater stations built along the Overland Telegraph Line.

8. Predictive modelling of the nature of Aboriginal sites/relics

8.1 Degree of preservation Aboriginal material culture

Items of organic material culture, such as wooden spears, digging sticks and small bags and nets will not have been preserved in the moderately acidic open-air sediments found in the project area.

However, various stone artefacts are likely to occur in the general region and will be preserved indefinitely:

- Macroblades (Mulvaney and Kamminga 1999:Map 12)
- Hatchet heads
- Unifiacial and bifacial points (Mulvaney and Kamminga 1999:Map 12c)
- Unretouched and retouched flakes used for light-duty cutting

- A number of other flaked stone tool type
- knapping debitage
- grinding stones

Stone quarry

Background research has indicated no likelihood for the occurrence of geological sources of stone suitable for Aboriginal stone tool making, hence stone quarries are highly unlikely to occur within or in the vicinity of the project area. There are recorded quarries distant from the project area in geologically complex areas near the McArthur River.

Culturally modified tree (scarred tree)

Culturally scarred old-growth trees may occur in the general area but generally will be difficult to identify with confidence (see scarred tree discussion in Appendix 2).

Aboriginal ancestral remains

Generally, Aboriginal people were buried in unconsolidated sandy sediment such as sand bodies along watercourses or in sand dunes occurring in other environmental contexts. The presence of human burials of relatively recent age within or in the general vicinity of the project area cannot be completely excluded. However, there is no evidence for the occurrence of strongly alkaline sediment that would be conducive to bone preservation. The pH readings of the surficial sediment taken at different locations in the project area were consistently 6.8, indicating slightly acidic conditions. Given the prevailing climatic conditions, in particular the high wet season rainfall, and the lack of ground-surface sheltering, and the physical and chemical character of the sediments, the preservation of bone remains is unlikely.

8.2 Incidence and size of stone artefact scatters and stratified sites

As well as the issue of stone availability, low human population density in prehistoric times equates to relatively low discard rate of stone artefacts such as flaking debris which typically marks the location of a former camping area.

A corollary of low population density in the study area is that a small number of spatially restricted base camps is the most likely prehistoric settlement pattern, along with small more transitory habitation sites. Both large and small camping areas would tend to be very close to water sources, especially during the dry season. The presence of the cluster of stone artefact scatter sites beside waterholes on the southern side of the Carpentaria Highway is evidence of such a settlement pattern.

Aboriginal hearths or remnants of hearths may be preserved in sandy sediment. Such hearths usually contain pieces of termite mound (e.g. Basedow 1907), or locally available stone.

Given the general environmental context, Aboriginal camping areas, and in particular ‘base camps’ occupied for more extended periods, would have been focussed on more permanent water sources such as watercourse channels, and waterholes during the dry season. Repeated occupation of favoured camping areas normally resulted in repeated discard of stone artefacts in areas where stone suitable for making stone tools occurs locally. The vast majority of preserved stone artefacts at camp sites are pieces, often quite small pieces, of stone waste ('débitage') created during the making and resharpening of stone tools, rather than the tools themselves.

Appendix 2 provides descriptions of the types of Aboriginal sites that have previously been recorded in this region.

The review of available data, particularly the sites recorded during earlier studies throughout this region, indicated that the range of Aboriginal cultural heritage sites more likely to be preserved within the project area includes:

1. Isolated stone artefacts.
2. Aboriginal hearths (earth ovens).
3. Stone artefact scatters. (sometimes associated with Potential Archaeological Deposits (PADs) comprising subsurface artefacts and other objects or features).
4. Scarred trees.

The background data review indicates that:

There appear to be no local sources of stone for stone tool making. All stone, other than ironstone for red and yellow pigment, would have had to be brought into the project area; possibly well beyond daily hunting and foraging distance from the encampment area. The potential distances of suitable stone sources are not known at this time, other than that sandstone possibly suitable for grinding stones and abraders; brittle siliceous stone with conchoidal fracture properties, and tough volcanic or metamorphic stone for ground stone tools, are likely to occur within the general area. The quarry sites previously recorded to the east of the project area are found in areas of siltstone and sandstone, not usually associated with quarries, except as quarries used for the projection of grinding stones.

In areas where more effort was needed to acquire stone by direct travel or through trade, it would have had increased value as a necessary material or commodity. This means that the stone tools used in the area are much more likely to have brought on site in a prepared state (rather than as unmodified or partially modified cores), hence there will be very little stone knapping débitage in campsites. Also, the stone tools were curated for longer to get the most use-life from them, making it most likely that those stone tools that are found will be small and highly reduced.

This general maxim indicates that suitable stone close at hand is more likely to have be knapped and the knapping débitage discarded in relative abundance in the areas around the sources of stone. There will be no large workshop sites in areas distant from the stone sources.

On the basis of the background environmental (particularly hydrological) and geological data it is concluded that only a small number of spatially-restricted base camps are likely to have existed and be detectable in this region. Such sites are unlikely to occur within the project area, but rather near waterholes in more substantial creeks. Preferred camping areas would have been located very close to the more reliable water sources, especially those used during the dry season.

Within the project area in general, the human population density would have been low overall, and consequently low discard rates of stone artefacts such as flaking debris and of grinding stones will have led to small, low-density and hence low-visibility sites.

9. Field survey methodology

An archaeological field survey was carried out within and around areas potentially subject to impact from work activities associated with the proposed exploration and drilling activities on Tanumbirini Station. This archaeological survey was undertaken by Principal Archaeologist Dr Johan Kamminga over a three-day period (6-8 March 2019). Mr. Trevor Edwards (Projects Specialist, Land Access & Management Services Pty Ltd) assisted in liaising with station staff and as guide and informant.

One main focus of the survey was the 10 km route of a proposed seismic line. This provided a transect across the Tanumbirini North Area from northwest to southeast, crossing all of the main land units present in the project area: Quaternary sediments, undifferentiated Cainozoic laterites, lateritic rubble and soil, and more resistant areas of Cretaceous lateritised claystone, soft grey claystone, sandstone and conglomerate (Figure 4).

Detailed inspection of areas along the seismic line allowed a comprehensive search for traces of prior Aboriginal visitation. These pedestrian surveys were conducted giving a coverage of approximately 5 m wide and perpendicular to the seismic survey line. Areas with relatively high ground surface visibility were selected as these offered the greatest possibility for the detection of small stone artefacts. Erosional scours were uncommon through this area. Generally, the recorded survey paths were sampled approximately between 100 and 200 m. Vehicle traverses were also carried out at a speed of approximately 5 km/hr. The vehicle traverses suited observation of the ground surface along tracks and road verges and also large expanses of flood overflow areas with exceptional ground surface visibility, generally around 100%.

Along survey routes and in other selected areas, mature trees were examined for evidence of cultural scarring. Tracks and sample locations were recorded using a hand-held GPS receiver, accurate to within 5 m. A low-magnification Wild M5 stereomicroscope was used to examine stone samples during the field survey (Plate 1).

In addition to the seismic survey line transect, areas along access tracks and a transect across the eastern portion of the Inacumba North Area were also inspected. The landscape setting of this area was similar to that found in the Tanumbirini North Area, with laterite gravel over much of the land surface. A number of sample areas were selected here and a detailed search for traces of prior Aboriginal visitation was undertaken. The environmental and landscape conditions of each sample area were recorded.

10. Results of the archaeological field survey

The nature and distribution of Aboriginal site types recorded on the registers and databases was reviewed during background research for this study. In reference to the environmental, geological and topographic contexts of the local and wider area, the types and distributions of sites/relics was predictable. As discussed below, the field survey has revealed no evidence for the presence of Aboriginal or non-Aboriginal archaeological sites/relics of any kind.

Ground surface visibility (GSV) within areas examined closely was generally good to very good (commonly 50-100% GSV).

The field survey corroborates the background research finding that there appear to be no local sources of stone for stone-tool making. All stone, other than ironstone for red and yellow pigment, would have had to be brought in to the area; possibly from well beyond daily hunting and foraging distances from the encampment area. The potential distances of suitable stone sources are not known at this time, other than that sandstone possibly suitable for grinding stones and abraders, and brittle siliceous stone with conchoidal fracture properties (located approximately 30 km to the east), and also volcanic or metamorphic stone for ground-stone tools, may occur within the general region.

In areas where a greater effort was needed to acquire stone by direct travel or by barter, that stone would have had increased value as a necessary material or commodity. This means that the stone tools used in the area are much more likely to have been pre-knapped, hence very little

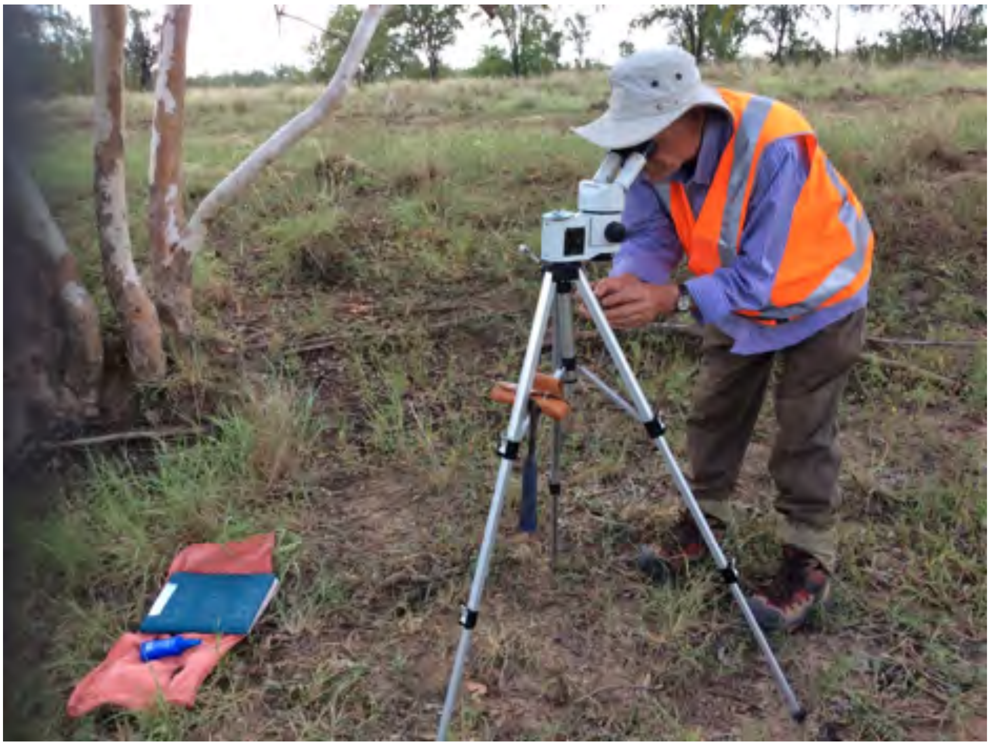


Plate 1. Low-magnification microscopic examination of natural stone occurring in a creek bank in the Tanumbirini North Area.

Plate 2. Area of clear ground surface visibility within a washout adjacent to a small watercourse in the Tanumbirini North Area.

Plate 3. Area of exposed ground at the Tanumbirini 1 well.

Plate 4. Meandering steep outer side of bend in a creek channel where ironstone lag has been concentrated on the more gently inclined inside slope of the channel. No Aboriginal stone artefacts were found in this location, despite the clear ground surface visibility on the ironstone gravel pavement.

Plate 5. Ironstone gravel lag pavement in a washout in the Ianumbirini North Area.

Plate 6. Actively migrating creek channel, exhibiting erosion causing tree fall and a steep outer channel margin exposing depth of loose clayey sand sediment. Located in the Tanumbirini North Area. Aboriginal stone artefacts are absent in the section along the channel bank or within the channel.

Plate 7. Termite mounds in the Ianumbirini North Area. Termite mounds are ubiquitous throughout this region.

Plate 8. Dense pavement of rain-washed ironstone gravel adjacent to the Tanumbirini 1 Well.

stone knapping débitage would be found in the camps. Also, the stone tools would have been curated for longer to get the most use-life from them, making them fewer and smaller.

The rule more or less means that high stone artefact densities and larger sites are more common in areas with abundant raw materials, while in areas with sparse or distant raw material soures, these sites tend to be smaller, with more heavily curated and smaller tools.

It was noted that almost all of the project area would not have been suitable for sustained or repeated encampment during prehistoric times. The watercourses in the area were mostly ephemeral first-order streams flowing northeast and they tended to be dry for extended periods.

The surficial soil layer over much of the project area appears to be shallow to very shallow, though less so along watercourses.

Termite mounds and ant nests (Plate 7.) are ubiquitous throughout much of the survey area, indicating that intensive invertebrate bioturbation of the loose sediment of the biomantle has been occurring over thousands of years up to the present time (c.f. Cahen & Moeyerson 1977; Dean-Jones & Mitchell 1993:43, 46; Mitchell 1988:52; Moeyersons 1978; O'Connell *et al.* 2018). As a consequence of this ongoing low-intensity long-term invertebrate bioturbation, many or most Aboriginal artefacts are not likely to be in their original stratigraphic context (cf., O'Connell *et al.*

2018).

11. Conclusions

No World Heritage Properties or National Heritage Places are registered within 10 km of the project area (see also Santos 2018:39). In addition, a search of the Northern Territory Heritage Register (DTC 2018) for NT Portion 701 (on which the Tanumbirini project area is located) was conducted and no previously recorded Aboriginal heritage items or places have been found in the project area (Santos 2018:39).

During the archaeological field survey, no Aboriginal or non-Aboriginal sites/relics were identified in the project area. It is considered that the survey coverage provides a good indication of the distribution of habitation sites through the areas likely to be affected by exploration and construction activities. The field survey has revealed that if there are traces of Aboriginal habitation in the project area, they occur at very low densities and/or are very localised. If this is the case, as we would argue, it is considered very unlikely that Aboriginal and non-Indigenous sites and relics would be disturbed or otherwise affected by the work associated with the proposed activities in the Northern Locations of the Santos McArthur Basin work program.

12. General recommendations

In general, ground surface visibility was relatively high in the areas examined. It is notable that no Aboriginal or non-Aboriginal sites/relics were identified during the survey. It is recommended that no further archaeological survey is required, unless Aboriginal or non-Aboriginal sites/relics are uncovered during proposed works activities.

While there were no traces of prior Aboriginal habitation detected during the field assessment, it is necessary to proceed with due care when undertaking works in the project area. In particular, any Aboriginal site/relic identified during the activity must be reported to the Santos Cultural Heritage Team so appropriate protection measures can be implemented.

It is advisable that a cultural heritage awareness program is provided to all those involved in ground disturbance activities to ensure that should Aboriginal sites and relics be uncovered during earthworks, that workers are trained to recognise the likely cultural heritage items and be aware of their responsibilities for reporting all exposed sites and relics.

If any human skeletal remains are encountered, work must stop immediately, the area secured to prevent unauthorised access, and the Northern Territory police contacted.

13. References

Basedow, Herbert 1907. Anthropological notes on the western coastal tribes of the Northern Territory of South Australia, *Transactions of the Royal Society of South Australia*, 31:1-64.

Guse D. and A. Collis 1998. Archaeological survey of proposed NABRE seismic lines, McArthur River Region, NT. A report for the North Australian Basins Resource Evaluation. Australian Geological Survey Organisation. Quaternary Archaeological Surveys, Casuarina, NT.

Isbell, R.F. 1993*. A Classification System for Australian Soils (Third Approximation)*. CSIRO Division of Soils Technical Report 2.

Kamminga, Johan 1979. The nature of polish on prehistoric stone tools; and 'Commentary on tool design and microscopic residues'. In *Lithic use-wear analysis*. Brian Hayden (ed.), Academic Press, New York, pp. 143-57.

Kamminga, Johan & Allan Lance 2016. Vickery Extension Project – Scarred tree assessment. Report to Whitehaven Coal Limited. Heritage Consulting Australia Pty Ltd. May 2016.

Mulvaney, John and Johan Kamminga 1999. *Prehistory of Australia*. Allen & Unwin, Sydney.

NT Parks and Wildlife Commission 2005 *Bullwaddy Conservation Reserve Plan of Management*. Parks and Wildlife Commission of the Northern Territory, Katherine.

NRETAS (2010). *Ucharonidge Station Number 1 Bore and 1949 Comet Windmill: Background Historical Information*. Heritage Branch, NT Department of Natural Resources, Environment, the Arts and Sport, Darwin.

Paine, A.G.L. 1963 Tanumbirini N.T. 1:250 000 Geological Series, Explanatory Notes. Bureau of Mineral Resources, Geology and Geophysics, Canberra.

Pensalfini, Rob 2004. Eulogizing a language: the Ngarnka experience. *International Journal of the Sociology of Language*, 164:141–156.

Pensalfini, Robert J. 1997. *Jingulu grammar, dictionary, and texts*. Massachusetts Institute of Technology.

Sharpe, Margaret 1969. Alawa phonology and grammar. PhD Thesis, School of English, Media Studies and Art History, The University of Queensland.

Santos 2013. Exploration Permit 161– Tanumbirini 1 exploration well environment plan summary. ENV-EP161 TAN 0003. Report to N.T. Department of Mines and Energy, Darwin.

Santos 2016. Exploration Permit (EP)-161 2016 Stratigraphic Corehole Program. Environment Plan Summary.

Santos 2018. NT Exploration Permit 161. Tanumbirini North Water Bore Monitoring Program.

Environnent Management Plan. Document No: MAB-PLN-005.
https://dpir.nt.gov.au/__data/assets/pdf_file/0005/370589/ep161-marmbulligan-environment-plan-summary.pdf

Sutton, Peter and Bruce Rigsby 1979. Linguistic communities and social networks on Cape York Peninsula. In S. Wurm (Ed.) *Australian linguistic studies*. *Pacific Linguistics*. Canberra, pp. 713-732.

Tasker, M.C. 2017. Application to clear pastoral land (s.38(1)(h) Pastoral Land Act). Application to the Pastoral Land Board Northern Territory, Darwin, by manager of Tanumbirini Station.

Tindale, Norman B. 1974. *Aboriginal Tribes of Australia: their terrain, environmental controls, distribution, limits, and proper names.* University of California Press, Berkeley.

Tindale, N.B. 1974. «Kotandji (NT)». *Aboriginal Tribes of Australia: Their Terrain, Environmental Controls, Distribution, Limits, and Proper Names*. Australian National University, Canberra.

Wood, B., D. Siverisen and C. Olsen 1981 *Land Systems of the Upper McArthur River Catchment*. Conservation Commission of the Northern Territory, Darwin.

Appendix 1 - Glossary of technical terms

AAPA

The Aboriginal Areas Protection Authority (AAPA) is an independent statutory authority established under the *Northern Territory Aboriginal Sacred Sites Act*. The Authority is responsible for overseeing the protection of Aboriginal sacred sites on land and sea across Australia's Northern Territory.

Background scatter

Generally, a very low density, more or less continuous distribution of artefacts over the land surface. Although these artefacts do not constitute a 'site' they are given location details for research purposes and to fulfil legislative requirements.

Bifacial point

Flakes or blades retouched along both ventral and dorsal surfaces of a flake to enhance or give the artefact its pointed shape. They often have the flake's initiation surface (striking platform) platform removed by retouch and this proximal end of the point rounded.

Grinding stone

Top and bottom grindstones, pestles and mortars characterised by at least one use-work and abraded surface.

Hammerstone

A stone that have use-wear on the surface in the form of abrasion and pitting characteristic of hammer usage.

Hatchet head (Edge ground hatchet head)

have been shaped by the process of flaking, pecking and grinding (polishing). They generally have only one cutting edge that has been ground to a straight or moderately convex plan shape.

Knapping (of stone)

Flaking stone to make stone implements. This is done by striking a piece of stone with a stone hammer (dynamic load in freehand percussion), or by more delicately applying pressure with a small stone or a piece of wood or bone.

Lag

A lag deposit is the deposition of stones winnowed by physical action. Fluvial processes (as occurs in the Santos project area), aeolian processes, and tidal processes can remove the finer portion of a sedimentary deposit leaving the coarser stones behind.

Manuport

A stone or fragment of stone that does not occur naturally in an area and must have been carried in by humans. Natural occurrences of locally-exotic stones include emu gastroliths and Permian age ice-rafted ‘dropstones’.

NLC
Northern Land Council.

Northern Territory Archaeological Site Database
A database of sites recorded in the Northern Territory including location and description details. Sites are protected by Northern Territory *Heritage Act, 2011*.

Sacred Site
Areas of significance for sacred sites is considered through the process of securing a sacred site clearance certificate (SSCC) from the Northern Land Council (NLC) and an Authority Certificate from the Aboriginal Areas Protection Authority (AAPA). This process aims to prevent damage to, and interference with sacred sites, by identifying and setting out the conditions for entering and working on the land.

Site
An archaeological site is defined for this survey as having more than one archaeological object within am area of two square metres, or a concentration of artefacts with an average density five times greater than the average density of the background scatter. A site will have an identifiable boundary where either artefact densities decrease to the extent as to be classified as background scatter or environmental features determine the boundary.

Siliceous stone
Rock or stone that is predominantly comprised of silica, usually in the form of quartz crypto-, micro- or macro-crystals. Examples are vein and macro-crystal quartz, quartzite, sandstone, silcrete, chert and chalcedony. These are the stone types commonly used by Aborigine people for making into stone tools.

Stone artefact scatter
An area of stone artefacts scattered on the ground, usually within an area of ground surface erosion. These artefacts are very predominantly the debris from knapping stone to make stone tools. Not uncommonly the scatter is associated with stone artefacts that occur below ground surface, unless scattered across a bare rock surface.

Subject land
The land area that is the subject of proposed work activities or development.

Transect (survey transect)
A straight line or narrow section through an object or natural feature or across the earth’s surface, along which observations are made or measurements taken.

Unifacial point

Flakes or blades that have been retouched along the margins from one surface, either ventral or dorsal to give or enhance its pointed shape. They can be symmetrical or leaf shaped.

Appendix 2 – Aboriginal site types likely to occur in this region

Probably more than 200 million people have lived on the Australian continent since it was first settled more than 40,000 years ago. The material evidence of this human presence and activity is abundant and widespread. Because stone is a highly durable material, stone artefacts are found widely distributed across the continent and sometimes are highly concentrated in certain land units, and in particular areas within these land units.

An Aboriginal archaeological site is defined as any material evidence of past Aboriginal activity in a context or place where the activity occurred (Officer and Navin 1998). Thus, significant Aboriginal sites or places such as 'Dreaming or Story site' do not necessarily have associated cultural remains. However, the vast majority of Aboriginal sites are open-air camps, indicated only by stone flaking debris and discarded stone implements, or sometimes an intact hearth with burnt remains.

The range of Australian Aboriginal sites likely to occur in the subject area can be categorised as:

1. Isolated artefact (usually stone).
2. Isolated hearth.
3. Stone artefact scatter (sometimes associated with Potential Archaeological Deposit (PAD) comprising subsurface artefacts and other objects or features).
4. Aboriginal historical site (camp, residence, mission, etc).
5. Stone procurement place and stone quarry.
6. Shell midden.
7. Cave and rock shelter with cultural sediment
8. Ceremonial ground (sometimes with earth or rock constructions).
9. Scarred tree.
10. Hatchet head grinding locality
11. Aboriginal burial (Aboriginal Ancestral Remains).
12. Rock art site.

These generally recognised site types are described below.

1. Isolated find

An isolated find, usually a single artefact or other cultural object, is defined by the absence of associated artefacts, cultural deposits or archaeological features. These finds may be indicative of random loss or deliberate discard of a single artefact, the remnant of a now dispersed artefact scatter, or a subsurface sedimentary horizon containing artefacts. They may occur anywhere within the landscape but are more frequently encountered in landscape units containing stone artefact scatters.

A conservative approach to artefact identification is required for isolated finds, especially when the find is a piece of fractured quartz. When artefact-size pieces of quartz, particularly relatively unweathered fragments of vein quartz, occur naturally in the sediment an identification of quartz items as artefactual must be based on definite evidence of knapping.

A proportion of the artefacts deemed isolated finds are part of the background scatter or count of artefacts within a land unit. Background scatter or count refers to the widespread occurrence of artefacts that cannot be related to a focus of past activity involving stone discard. The 'background' is an accumulation of stone artefact loss and discards events occurring since first human settlement of that region, though erosion in a local area may only reveal artefacts from any recent prehistoric activity.

The type and frequency of isolated artefacts in a landscape unit will depend on a number of factors. These include the nature of past human settlement and exploitation in the region, the proximity and nature of the stone used for toolmaking, and a range of environmental factors such as the nature of sediments, degree of erosion and degree of ground surface visibility. Generally, there are no reliable estimates of background scatter for land units within different regions of Australia.

Isolated finds may indicate:

- loss or discard of an artefact while away from a camp (while travelling);
- an isolated tool-making or resharpening event away from camp, where a group of artefacts is discarded on the ground;
- an encampment area, where artefacts occur within the sediment (and present-day erosion is minimal).

2. Isolated hearth

Aboriginal hearths (fireplaces) are an important archaeological feature of encampments and provide a range of archaeological evidence about prehistoric settlement and subsistence. These features often provide material for chronometric dating of the occupation event (Mitchell 1996) and some isolated hearths are extremely ancient.

Identifying hearths or anthropogenic hearths generally from the remains of natural occurring fire is often problematic There is a range of anthropogenic hearth types, including cooking pits, heat-treatment pits, work and sleeping fires, and ash dumps. Natural fire, such as a slowly burning tree stump, can bake clay sediment and leave a feature comprising a discrete area of burnt clay with charcoal and ash. This same polythetic set of features occurs after European forest clearance and burning of dried timber.

One way of distinguishing human-caused or archaeological fire is by its shape and size. Archaeological fires tend to be roughly circular in shape on the upper surface and basin-shaped in cross-section. Hearths diameter ranges between 20 to 30 cm and about 5 to 10 cm in depth (Mitchell 1996). Archaeological fire features may also appear as lenses of concentrated charcoal, blackened or reddened rocks and clay heat retainers (baked clay lump), and may also contain stone artefacts, cobble manuports and less commonly charred bone and shell. The shape of clay nodules in such a feature can be used to distinguish archaeological fire mounds from a burnt tree feature. Clay heat retainers are rounded nodules while natural baked clay sediment tends to be blocky or irregular in shape. Not uncommonly stone artefacts are flaked beside a fireplace and discarded flaking debris may show evidence of heating.

Mitchell (1996) has identified a number of methods by which anthropogenic can be differentiated from natural fire. However, some of these methods have failed to produce a convincing or reliable result.

Magnetic susceptibility analysis of clay nodules fired at a temperature lower than 500ºC has failed to distinguish between natural and human caused fires (Mitchell 1996). However, other analytical methods that show promise are spatial analysis, macroscopic examination, microscopic analysis, particle size analysis and chemical analysis. For instance, spatial analysis may show clustering of charcoal patches, while macroscopic analyses can help identify rounded orange-red clay nodules as well as identify charcoal size range for analysis of particle size distribution. Experimentally, fire pits produced charcoal size larger than 3 mm. Microscopic analyses allow for identification of flaking microdebitage, fragments of charred bones and identification of species of wood that was burnt. In ideal circumstances, chemical analysis of baked clays can be used to identify organic residues such as exudates from tuber roasting.

3. Stone artefact scatter

When artefacts occur in sufficient concentration on a land surface unprotected by rock overhang the area is described as a stone artefact scatter. Other labels that have been used are: lithic scatter, artefact scatter, surface scatter, open site, open-air site, ‘open camp site, and ‘campsite’.

The stone artefact scatter is the most commonly reported Aboriginal prehistoric site type in Australia. In some regions devoid of rock shelters or caves, open sites (or stone artefact scatters) may be virtually the only type recorded in archaeological surveys. Stone artefact scatters are most likely to occur on level or low gradient land surfaces, along the crests of elevated flats on hills, ridgelines and spurs, in coastal sand dunes, and on slightly elevated flattish ground fringing watercourses and wetlands. Larger stone artefact scatters with subsurface artefact horizons tend to occur in the vicinity of major and/or reliable water sources.

Stone artefact scatters represent a range of different human activities or site uses. However, most are former open-air campsites, ranging in nature from a day camp by an individual or small group during a hunting and gathering trip, to a large, semi-sedentary base camp located at a reliable water source. Some important camping areas were reoccupied on a regular basis over hundreds or even thousands of years.

Often, a scatter of stone artefacts and manuports (such as pebbles and burnt clays heat retainers) lying on the ground are the remains of an uppermost horizon of soil stripped of all but its heaviest items by wind and water erosion. In many instances, the artefact horizon is not removed entirely and there is still a horizon of artefacts (sometimes disturbed) and associated cultural features such as hearths in various spatial concentrations of habitation debris. Where a stone artefact scatter has an identifiable or inferred subsurface cultural horizon as well as artefacts on ground surface, the two kinds of archaeological deposit (surface and subsurface) comprise a single 'site'.

Usually a visual inspection of the artefacts on ground surface is not sufficient to accurately determine the extent of the subsurface concentration of artefacts. Commonly, the boundary of the subsurface cultural horizon is not well defined, and the count of artefacts gradually decreases with distance from a main concentration until it merges with the average background count for a land unit.

The stone artefacts and manuports in stone artefact scatters represents stone flaking and discard activities associated with manufacture and maintenance of tools, weapons and other items of material culture, or for processing plant food. The remains of hearths, and other cultural features, also may be present within the general area of the site. Artefact density can vary considerably across a site and between different sites in the same land unit.

Stone artefact scatters normally cannot be dated with any precision (within the last few thousand years is common) and they are often difficult to interpret from the small sample of material remains. While the site's size and its 'density' of artefacts are often taken as reflecting more intensive use of the site by people, a wide range of factors bears upon artefact density and site size, sufficient to limit any interpretation in the absence of professional excavation.

3.1. Bioturbation impact on site integrity

Determining the original positions and sequence in which artefacts were deposited at an open-air site often is complicated by a number of disturbance processes, such as downward soil creep on slopes, cracking of topsoil, tree growth, burrowing animals (in particular invertebrates), and human activity. Bioturbation of the soil horizon by ants, worms and termites is a significant cause of artefact sinking and mixing in soil layers (Cahen & Moeyerson 1977; Dean-Jones & Mitchell 1993:43, 46; Mitchell 1988:52; Moeyersons 1978; O'Connell *et. al.* 2018). Kamminga provided the first demonstration of invertebrate bioturbation of an open-air prehistoric site in southeast Australia (Kamminga *et al.* 1989:32-33), and there are a few other documented examples.

Tree growth and tree fall also cause bioturbation of cultural sediments (e.g. Photo 7). Gollan (1992:44) has estimated that in forested land of at least 100 trees per hectare tree growth would have would have caused extensive disturbance of sediments over a period of approximately 2,500 years. Dean-Jones and Mitchell (1993:43-44) have reported that tree fall tends to cause mixing of cultural objects (usually stone artefacts) out of stratigraphic order when sediment is washed from the tree roots by rain. There are specific instances where this has been observed in action (Kamminga *et al.* 1989:27, 32-33). It should be noted however that most trees species in Australia do not significantly disturb the soil when falling, because the trunk breaks after weakened by fire, fungi and termites, and tends to remain in the ground.

In general, it is difficult to assess the effects of plant and animal bioturbation within open-air sites without first undertaking test excavations. in the first identification of invertebrate bioturbation of an open-air site in south-eastern Australia, Kamminga found by plotting artefacts weight distributions that there was a marked vertical dispersal of the lighter fraction (less than a gram) above and below a well-defined horizon of the heavier Aboriginal objects (Kamminga *et al.* 1989:32). This pattern could only be accounted for primarily by earthworm bioturbation. However, the effects are not always so clear. Bioturbation impacts are often relatively small-scale vertical and lateral movement of artefacts. In particular, invertebrate burrowing can result in different sizes and shapes of stone fragments sinking into the soil at different rates and eventually settling at the same level which is normally the lower limit of invertebrate activity (see review in Kuskie and Kamminga 2000).

3.2. Effects of ploughing on subsurface artefact horizons

Human activity at a site in prehistoric times may disturb original material patterns of former occupation. Manuports and artefacts may be moved around a camp during subsequent visits, re-used or even removed. In circumstances where site integrity is high, this subsequent activity may be inferred from the character and pattern of the preserved archaeological record. However, where bioturbation or pastoral practices have diminished site integrity, practically none of this may be evident.

Ploughing occurred soon after vegetation was cleared, especially on floodplains and lower slopes. Ploughing causes both vertical and horizontal movement of artefacts and manuports and is therefore a major cause of disturbance to artefact horizons within 20-30 centimetres of the ground surface. While the stump-jump plough cut a furrow no more than about six centimetres deep, later designs of ploughs and inevitable loss of some topsoil has meant that open-air sites in cleared land tend to be seriously disturbed. Ploughing causes both vertical and horizontal movement of artefacts and manuports, resulting in disturbance to original patterns of discard, either in their original discard configuration or after already affected to some degree by natural processes. Ploughing can also cause the destruction of archaeological features such as fireplaces. After several decades of ploughing, artefacts may be displaced laterally up to several metres. For all types of ploughing equipment, larger artefacts (more than 40 mm in size) tend to be moved the greatest horizontal distance (Roper 1976, Lewarch 1979:116-122, Lewarch & O'Brien 1981a, b). Smaller cultural objects tend to displace downward (Roper 1976). Ploughing also tends to destroy hearths and other cultural features in open-air sites.

4. Aboriginal historical site (camp site, mission site, etc)

Aboriginal lifestyle and settlement patterns changed significantly as British settlers colonised the continent. Surviving Aboriginal people often lost access to their traditional hunting and foraging territories and a dependant relationship developed with the British settlers and colonial government. Aboriginal people settled in family groups on farms and camps were located at some of the British settlements.

In Australia, 'contact-period' base camps with intact old growth forest or woodland surrounding them tend to have a relatively large number of scarred trees in the vicinity. Artefact scatters may contain shells and the remains of hearths with burnt clay, and an assortment of items of British or colonial manufacture, such as buttons, clay pipe fragments, nails and other pieces of iron, and bottle and ceramic fragments. However, for a number of reasons, in northern interior NT scarred trees may not be that common in the vicinity of base camps.

5. Stone procurement place and stone quarry

Throughout Australia various stone and mineral substances were collected and sometimes quarried to make stone implements and pigments of various kinds (Hiscock and Mitchell 1993; Mulvaney and Kamminga 1999:27-31). Sandstone also was quarried in large slabs for use as grindstones in milling seeds for flour. Gravel beds and bars in watercourses were often ideal places to collect suitable stone, because they usually provided a choice of different stone types, and size and shape of pebbles and cobbles that had been water transported and therefore naturally tested for toughness. In areas where waterworn stones were collected from stream beds and relict river gravels the rejected and discarded flaking debris is often scattered about at or near the stone source. Where particularly desirable stone occurs, the discarded flaking debris may comprise thousands of items per square metre. Some larger stone collecting localities in the arid zone were extensive rock formations, where knapping debris is scattered over the ground for many kilometres. Rarely, stone procurement sites have quarry pits and shafts following a seam of high-quality stone or ochre. Around these pits are knapping floors or 'stone reduction sites', where the early stages of tool manufacture occurred. However, often prehistoric stone procurement places, and at creek beds in particular, there is little or no archaeological evidence of stone procurement: there are no concentrations of preliminary knapping debris and no quarry depressions or pits.

Certain Aboriginal quarries and mines possessed significance that transcended material needs. People did not always prefer the closest source but exchanged valuable goods or travelled through arid country to a more distant source for stone they believed was imbued with spiritual power.

6. Shell midden

Coastal and freshwater shell middens comprise mostly the remains of women's shellfish collecting activities.

Many of the larger coastal middens along the seaboard of south-eastern Australia have been quarried to obtain shells for lime burning and land fill. Typically, middens are located in coastal estuaries and on headlands and sand dunes along the coast, and inland within riparian zones of watercourses and the margins of lakes with relatively permanent water. Middens and shelly lenses may occur out in the open or in rock shelters. Sometimes a midden deposit is minimal, comprising only a thin shelly layer or lens, as is common for inland lakes or riverside spreads of mussel shells. In other instances, middens are massive in size.

6.1. Types of middens

Ethnoarchaeological research in Arnhem Land has identified two kinds of Aboriginal shell middens – 'base camps' which were occupied continuously for long periods, and 'dinnertime camps', representing ephemeral campsites (Meehan 1982). These ethnographic categories are often used as a rule-of-thumb guide for interpreting prehistoric middens elsewhere in Australia.

Despite the importance of middens for archaeology and the impressive size of many of them, shellfish usually provided only a small part of the Aboriginal subsistence base. While shellfish are a staple food resource, they contributed probably no more than one tenth of dietary needs in most coastal regions. Of course, they were a more significant resource during lean times. Other littoral and marine resources were important to coastal people, as were the plant foods and game obtained from wetlands and adjacent forest or woodland environments both on the coast and inland.

6.2. Antiquity of middens

Accumulations of shell tend to preserve well over a long time because they generate their own alkaline sedimentary environment even in surrounding acidic sediment. Thus, middens and their carbonaceous content of shells, animal and human bones may survive for millennia. Because they fringe the present-day seashore the majority of coastal middens are less then 6,000 years old. Some inland middens are more than 20,000 years old but, like coastal middens, most of those located belong within recent millennia.

6.3. Midden identification criteria

Occasionally there is difficulty in distinguishing midden deposit from natural features such as shelly storm beach deposits and scrub fowl mounds. Sometimes a midden cannot be a natural formation because of its particular location. Commonly agreed criteria for the identification of Aboriginal midden deposits include the range of species (preference for edible, mature shellfish), usually restricted to one or two species such as oyster, *Anadara*, whelk and turbo shells, or freshwater mussel. This concentration of edible sized shells usually produces positively skewed size-frequency distributions. Natural shell accumulations by wave action are likely to contain random species and size samples. Other criteria for midden deposit are layers indicating cultural rather than natural deposition, the presence of stone and bone artefacts, and manuports (natural stone brought by humans, often as cooking stones), and the presence of various crustacean, fish, bird and mammal remains that are not likely to occur naturally.

7. Cave and rock shelter site with cultural sediment

True caves, created by water action and dissolution, are commonly found in limestone country. Large caves occur along the southern coast from Victoria to southwest Western Australia and others in Cape York Peninsula and southern Tasmania. Rock shelters are far more numerous and widespread than true caves. These shelters are formed by cavernous weathering by wind and water, usually of sedimentary rock such sandstone or quartzite, or by the inclination of large boulders.

While caves and rock shelters are of particular interest to archaeologists they were not necessarily commonly used as campsites in prehistoric times. In general, Aborigines did not inhabit the deep and dark recesses of caves, but camped at their entrances, venturing deep into their passages only for special purposes. In some desert areas, rock shelters were normally inhabited only during heavy rain or dust storms and over a period of thousands of years may have been visited only occasionally.

The reason archaeologists concentrate on such places is that the accumulation of stratified and datable sedimentary deposits containing stone artefacts and other occupation debris are concentrated within a very limited area; in some case the cultural material in the deposit is sparse, in other cases it is abundant. The alkaline sediment in limestone caves and shelters preserves bone and shell much better than in other depositional contexts; in very dry cave deposits a wide range of organic materials may be preserved, including dried plant matter such as wood and resin. While most caves and shelters contain shallow deposits, excavations may penetrate many metres of cultural horizons containing food debris of animal bones and shells, plant materials and microscopic pollen and phytoliths (plant silica), ash and charcoal from campfires, debris from knapping stone, and discarded stone implements. These cultural materials provide the basis for reconstructing prehistory.

8. Ceremonial ground

Ceremonial rock arrangements and earthworks are found in many parts of Australia (Mulvaney and Kamminga 1999) and historical records and field surveys indicate that they occur commonly in parts of eastern Australia. Over a thousand are known from NSW and Queensland alone. Many former ceremonial grounds had no features or constructions, and their existence and location are evident only from historical records.

Ceremonial constructions such as rock arrangements and earthworks are always low features in the landscape and usually less than a metre high. There are however a range of different designs. Some were personifications of totemic beings who participated in creation dramas; others demarcated areas for particular ceremonial activities. The latter function possibly explains the many linear or circular arrangements of stones enclosing a clear area ranging from a few square metres to hectares in area. Many earth or piled stone features in Australia are identified as bora ring because of historical accounts of ‘bora’ ceremonies (initiation of boys) at such sites.

Construction of stone lined paths and concentric rings of earth or stones involved considerable labour to construct. Linear earthworks or pathways may link pairs of circles, one larger than the other.

There are also many examples of cairns, or large, single standing stones, some of which have religious associations.

The simpler the construction or feature the more difficulty it is to identify it as an Aboriginal relic. Some constructions have no distinctive cultural attributes and without confirmation from informants, they would be unrecognised as Aboriginal or even cultural features. The location and survey of stone arrangements, ranging from simple cairns to elaborate ground designs are a continuing challenge for archaeologists.

9. Scarred tree

Scarred trees are conspicuous markers of Aboriginal inhabitation of country that is now substantially different from its original state. As Long (2002:5) has noted, there are few agricultural regions in the world where the native living plants display in their fabric pre-modern human activity.

Scarred trees occur within the remnant forestlands and woodlands, and generally more frequently along the sea coast and close to reliable water sources such rivers, billabongs and swamps. However, they may occur almost anywhere. Following widespread clearance of forest and woodland, the number of mature trees suitable for bark removal would have been dramatically reduced. Culturally scarred trees are more likely to survive in state forests and reserves of various kinds (including road reserves). Thus, the few identified scarred trees have been found within remnant areas of native woodland and in narrow road reserves (c.f. Edmonds 1998:47; Kamminga and Grist 2000:78-80, 95-100; Paton 1993:17-18, 23, 25-26; Long 2002, 2005).

The wide range of uses to which bark was put is reflected in the size range of the scars, which for making canoe hulls can be up to six metres in length and two metres in width. 'Canoe trees' are concentrated along rivers and other suitable water bodies. Rectangular sheets also were used as roofing and walls of huts and shelters in regions in Australia with suitable tree species. Andrew Long postulates that large mature trees with straight trunks were chosen for construction sheets, and that commonly the width of the bark sheet was 50-75% of the tree's circumference (Long 2002, 2005).

Smaller sheets cut from a curved trunk or thick limb and from burls were made into containers (carrying vessels) such as bowls and dishes. Other small sheets were used as supports for drying and scraping animal skins (mostly possum), at least in northern Victoria and the Hunter Valley in NSW where they have been documented, but probably more widely, and for bark shields in parts of south-eastern Australia. While bark artefacts of these kinds are widely documented in Australia, less conspicuous or minor uses of bark were for grave pit lining, carved bark sculpture used in corroborees, and cord and rope (the bark was stripped off the tree for making fishing lines, nets, string, climbing rope, etc). Other types of Aboriginal scarring include toeholds cut into the trunk or branches for climbing in pursuit of possums and other small arboreal animals or collecting eggs, nuts and honey, and resource extraction holes (Kamminga and Grist 2000:57; Long 2002, 2005). These features sometimes occur in association with bark procurement scars, and most often exhibit cut marks from a steel axe or hatchet.

Bark was procured from a range of tree species, some of which, such as River Red Gum, and species of box, stringybark and paperbark, were particularly useful for making constructions and artefacts. Inevitably, due to natural death of trees, insect attack, bushfires and agricultural clearing, the number of scarred trees has diminished rapidly, and often they are now only encountered along wooded watercourses, and on the margins of lakes and swamps. Despite this dramatic reduction in numbers these relics are still being recorded in large numbers during archaeological field surveys.

Reliable identification of scars as Aboriginal is notoriously difficult Kamminga and Lance 2016), with considerable consequence for assessment of site significance and potential environmental impacts from development. It is often very difficult to distinguish Aboriginal culturally scarred trees from those made by or for settlers, who used bark most as cladding and roofing material (Kamminga and Grist 2000; Long 2002:3). Scars from the effects of fire, lightening, limb fall, faunal activity and modern human activity often have been wrongly interpreted as Aboriginal. Also, the bark around cultural scars regrow as 'callous tissue', especially around the sides of the scar – this regrowth often obscures the original shape of the scar and hatchet cut marks in the underlying wood. Over time the wood within Aboriginal scar degrades by weathering, bushfire or insect infestation, so that the essential for identification is lost. Finally, there are considerable difficulties in determining the age of living or dead scarred trees. Little information has been compiled on the maximum life spans of the tree species Aborigines exploited for bark, and in particular box and gum trees. Aboriginal Affairs Victoria advised in mid-2007 that only definite Aboriginal scarred trees should be registered. The manuals by Andrew Long, 'Scarred trees: a field identification manual', and 'Aboriginal scarred trees in New South Wales' are essentials guide to identifying and evaluating Aboriginal scarred trees (see also Kamminga and Grist 2000:56-65; Officer and Navin 1998:14; Officer 1992).

10. Hatchet-head grinding locality

One of the most important Aboriginal implements was the ground-stone hatchet, which is more commonly but less correctly known as the 'edge-ground axe' (Mulvaney and Kamminga 1999:32-34, 91-93). On current evidence, this implement first appeared in south-eastern Australia about 4500 years ago. The processes of fashioning and resharpening the hatchet head included the grinding of a cutting edge on an abrasive stone, usually found near water and close to campsites. At these places grinding grooves are worn into bedrock, which often is sandstone.

11. Aboriginal burials (Aboriginal Ancestral Remains)

In general, Aboriginal people regard burials as an extremely significant and sensitive site types (Mulvaney and Kamminga 1999:35-38) and removal of Aboriginal remains for reburial are undertaken only with guidance or supervision from the relevant Aboriginal community. There are also strict legal obligations relating to the recovery of Aboriginal and non-Aboriginal human remains.

Historical evidence indicates great diversity in Aboriginal mortuary practice throughout the continent during early historical times (Hiatt 1969). Burial practices included cremation bodies wrapped in soft bark, skin or matting and buried in a shallow grave, or cached within a hollow tree trunk or ossuary in rock crevices.

Ordinarily such remains are not encountered in archaeological excavations. However, development work and erosion continue to expose prehistoric human remains. Human burials are generally only visible where sub-surface sediments have been disturbed or where an erosional process has exposed them. Most often, they are found in rock shelter deposits and in sand bodies and in sandy or silty sediments. In valleys and plains, burials may occur in locally elevated topographies rather than poorly drained sediments. Burials rarely occur on rocky hilltops.

While the majority of recorded burials date to within the last few thousand years some are much more ancient. Large cemeteries occur along the Murray River, many of which had been established for millennia. A small number of Aboriginal cemeteries have been located in other regions and it is expected that in future years more will become apparent.

Study of such remains provides information about prehistoric nutrition, diseases, injuries, and long-term biological changes. Such studies also provide information about the nature of material culture, and cultural practices and belief systems of past generations. Fibre, animal skin and wood usually disintegrate rapidly after burial, and most graves lack surviving material relics. However, stone, animal bones, bone fishhooks, shells, pellet and powdered ochre, teeth necklaces, and bone pins and points have been recovered from some burials (Mulvaney and Kamminga 1999:35-38). The kinds of information gained about prehistoric culture and society are of importance not only to Aboriginal people but the wider Australian community.

12. Rock art site

Aboriginal rock art is the pictorial record of Australia's human past, and as such is a unique component of the archaeological record (Mulvaney and Kamminga 1999:369-82). This artistic expression provides insight into aesthetics and other social practices and beliefs. Innumerable rock art motifs survive throughout Australia as paintings, drawings, and pecked and abraded 'engravings', on open and sheltered rock surfaces. In most areas of Australia, paintings and engravings are intimately tied to contemporary Aboriginal beliefs and rituals of group or self-identity, sometimes requiring the periodic rejuvenation of motifs. Most surviving rock art in Australia dates within the last 3,000 years. Recent dating of thin encrustations on paintings demonstrates an antiquity of at least 25,000 years for some art in Cape York.

Much of the current research on Aboriginal rock art concerns the discovery, preservation and recording of the art. While many thousands of sites are on State site registers, only a fraction is individually recorded or described, while their conservation raises great problems. More than any other site type, Aboriginal rock art is part of the tourism industry in Australia and is widely recognised for its Aboriginal, aesthetic, scientific, historical and educational values.

The preservation of rock art is dependent on a combination of environmental factors including weather, surrounding plant communities, insect and animal activity, and the geological structure and durability of rock surfaces. Some art is preserved beneath a natural hard coating of silica that has built up on the rock surface. However, rock art usually deteriorates, sometimes at an alarming.

Images were made on rock surfaces by two basic methods – the application of substances such as pigment or beeswax, and the physical removal of the rock surface by pecking or pounding. Pigment was mixed and applied as a liquid medium to form paint, or else drawn using a dry crayon or charcoal. Paint was also blown from the mouth around an object to create a stencilled negative. Almost all the red, yellow and brown pigments are derived from iron-rich minerals, like hematite ($Fe^{2}2O^{3}$), commonly known as ‘red ochre’, siderite, a yellow-coloured iron carbonate, and goethite, a yellow to brown mineral which forms naturally as a weathering product from the other iron minerals. An impure version of goethite, the mineral limonite, which has a vitreous lustre, was also used. The colour of hematite paint ranges from various shades of red to mulberry, and even to blackish when the pigment has aged on a rock surface. Hematite is chemically stable and is durable on rock surfaces because its microscopically platy structure provides strong adherence properties. Charcoal, which normally provides black colouring, was ground and mixed as paint or applied from a charred stick. White mostly comes from kaolin clay. Some carbonate minerals have been identified, such as huntite, dolomite and calcite, which were ground to powder and mixed with water. All these white paints have poor preservation and poor adhesion, so they tend to flake off surfaces. Consequently, white pigment usually indicates that motifs are relatively recent.

Rock engraving involves pounding or ‘pecking’ the rock surface to expose lighter-coloured unweathered rock. The most common engraving technique was to pound a narrow groove as an outline of the motif. Intaglio, or the pecking of an area of stone to form a negative impression of the image, was also practiced. Engravings are found commonly on stone softer than quartzite (sandstone, limestone, various indurated sediments, fine-grained granite and dolerite) and where the sub-surface is much lighter in colour than the weathered ‘skin’, so that the visual effect is dramatic. Sometimes a rock pavement that was particularly favoured or ritually significant is densely engraved for over hundreds of square metres.

Stencils are a specialised technique for creating an image of a real object, distinct from most other forms of art which rely on the free-hand interpretation of the artist. Most stencils are of hands; others are of animals, plants and artefacts. Hand stencils probably represent a pictorial signature, and ones of hematite may last for many thousands of years. The most elaborate use of stencil motifs in a narrative or artistic composition occurs in the sandstone country around the Carnarvon Range in southern Queensland.

Appendix 2 - References

Bell, David 1979. Aboriginal carved trees in New South Wales: a survey report. Part 1. Report to NSW National Parks and Wildlife Service.

Berndt, Ronald and Catherine Berndt 1996. *The world of the first Australians. Aboriginal traditional life past and present*. Aboriginal Studies Press, Canberra.

Cahen, D. and J. Moeyersons 1977. Subsurface movements of stone artefacts and their implications for the prehistory of Central Africa. *Nature*, 266:812-5.

Clarke, Philip 2003. *Where the ancestors walked*. Allen and Unwin, Sydney.

Dean-Jones, P. and P.B. Mitchell 1993. Hunter Valley Aboriginal sites assessment project: environmental modelling for archaeological site potential in the central lowlands of the Hunter Valley. Unpublished report to NSW National Parks and Wildlife Service.

Edmonds, Vanessa 1998. The Wimmera River Cultural Heritage Study. Stage II. The Middle Wimmera Basin. Report to Goolum Goolum Aboriginal Cooperative, Horsham. Archaeological Consulting Services, Buronga, NSW. February 1997.

Frankel, David 1982. Earth rings at Sunbury, Victoria, *Archaeology in Oceania*, 17:89–97.

Frankel, David 1991. *Remains to be seen: archaeological insights into Australian prehistory*. Longman Cheshire, Melbourne.

Gollan, Klim 1992. Aboriginal cultural heritage study: northeast Forests, New South Wales. Unpublished report to NPWS.

Gorecki, Pawel and Mary Dallas 2000. Aboriginal archaeological assessment. Johns Road, Wadalba, NSW. Report to Wyong Shire Council, NSW.

Hiatt, Betty 1969. Cremation in Aboriginal Australia, *Mankind*, 7:104-19.

Hiscock, P. and S. Mitchell 1993. *Stone artefact quarries and reduction sites in Australia: towards a type profile*. Australian Government Publishing Service, Canberra.

Kamminga, Johan 2003. Aboriginal Heritage Study, Beachcomber Holiday Park, Eurobodalla National Park, NSW. Report to NSW National Parks & Wildlife Service, Far South Coast Region Office, Narooma. National Heritage Consultants, Canberra.

Kamminga, Johan & M. Grist 2000. Yarriambiack Creek Aboriginal heritage study and conservation plan. Kamminga Archaeology report to Aboriginal Affairs Victoria.

Kamminga, Johan & A. Lance 2016. Vickery Extension Project – Scarred tree assessment. Report to Whitehaven Coal Limited. Heritage Consulting Australia Pty Ltd. May 2016.

Kamminga, Johan, Robert Paton and Ingereth Macfarlane 1989. Archaeological investigations in the Thredbo Valley, Snowy Mountains. Anutech Pty Ltd report to Faraba Pty Ltd.

Kuskie, Peter and Johan Kamminga 2000. Salvage of Aboriginal archaeological sites in relation to the F3 Freeway near Lenaghans Drive, Black Hill, New South Wales. Southeast Archaeology Report to Major Projects, Northern Region, Roads and Traffic Authority of NSW. (3 vols).

Lewarch, D.E. 1979. Effects of tillage on artifact patterning: a preliminary assessment. In Cannon Reservoir Human Ecology Project-A regional approach to cultural continuity and change. In M.J. O'Brien and R.E. Warren (Eds), *Technical Report 79-14*, pp. 101-149. Division of Archaeological Research, University of Nebraska, Lincoln.

Lewarch, D.E. and M.J. O'Brien 1981a. The expanding role of surface assemblages in archaeological research. In Schiffer, M.B. (Ed.), *Advances in archaeological method and theory*. Volume 4. Academic Press, New York.

Lewarch, D.E. and M.J. O'Brien 1981b. Effect of short term tillage on aggregate provenience surface pattern. In M.J. O'Brien, and D.E. Lewarch (Eds), *Plowzone archaeology: contributions to theory and technique*. Vanderbilt University, Tennessee.

Long, Andrew 2002. *Scarred trees. A field identification manual.* Aboriginal Affairs Victoria. Compiled by Harry Webber. Department of Natural Resources and Environment, Melbourne. (The manual is available online).

Long, Andrew 2005. *Aboriginal scarred trees in New South Wales: a field manual*. Department of Environment and Conservation (NSW), Hurstville. Archive version: http://nla.gov.au/nla.arc-55351.

Meehan, Betty 1982. *Shell bed to shell midden*. Australian Institute of Aboriginal Studies, Canberra.

Mitchell, Catherine 1996. Interpreting charcoal patches on open-site archaeology: need we be stumped for an answer? BA Honours thesis, Department of Archaeology and Paleoanthropology, University of New South England.

Mitchell, P. 1988. The influences of vegetation, animals and micro-organisms on soil processes. In H.A. Viles (Ed.), *Biogeomorphology*. Basil Blackwell Ltd, Oxford.

Mulvaney, John and Johan Kamminga 1999. *Prehistory of Australia*. Allen and Unwin, Sydney.

Moeyersons J. 1978. The behaviour of stones and stone implements buried in consolidating and creeping Kalahari sands, *Earth Surface Processes*, 3:115-128.

O'Connell, James F. Jim Allen, Martin A.J. Williams, Alan N. Williams, Chris S.M. Turney, Nigel A. Spooner, Johan Kamminga, Graham Brown, Alan Cooper, 2018. When did *Homo sapiens* first reach Southeast Asia and Sahul? *Proceedings of the National*

Academy of Sciences, 115(34): 8482–8490.

Officer, Kelvin 1992. An archaeological investigation and management assessment of an Aboriginal scarred tree: 'Gunderoo Drive Four', Gungahlin, ACT. Navin Officer Archaeological Resource Management report to R.A. Young and Associates Pty Ltd.

Officer, Kelvin and Kerry Navin 1998. Cultural heritage assessment, Proposed Visy Pulp and Paper Mill, Gadara Plains, Tumut, NSW. Report to Nolan-ITU Pty Ltd.

Roper, D.C. 1976. Lateral displacement of artefacts due to plowing, *American Antiquity*, 41:372-375.

Tindale, N.B. 1974. *Aboriginal tribes of Australia. Their terrain, environmental controls, distribution, limits and proper names*. University of California Press, Berkeley.

Santos

Appendix G: Wastewater Management Plan

Santos

Wastewater Management Plan: McArthur Basin Hydraulic Fracture Program

NT Exploration Permit (EP) 161

Date	Rev	Reason for Issue	Author	Checked	Approved
15/07/2019	0	For Submission	DG	PW	DC
2/10/2019	1	For Submission	DG	PW	DC

Table of Contents

Tables

Figures

Appendices

Abbreviations and Units

Acronym / Abbreviation	Description
ALARP	As low as reasonably practicable
ALRA	Aboriginal Land Rights Act
AAPA	Aboriginal Areas Protection Authority
APPEA	Australian Petroleum Production and Exploration Association
CLA	Cambrian Limestone Aquifer
CoP	Code of Practice: Onshore Petroleum Activities in the Northern Territory
CPESC	Certified Professional in Erosion and Sediment Control
DENR	Department of Environment and Natural Resources
DoEE	Department of Environment and Energy
DFIT	Diagnostic Fracture Injection Test
DPIR	Department of Primary Industry and Resources
D&C	Drilling and Completions
EC	Electrical Conductivity
EMP	Environmental Management Plan
EP	Exploration Permit
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
EPS	Environmental Performance Standards
ERA	Environmental Risk Assessment
ESD	Ecologically Sustainable Development
ha	Hectares
GISERA	Gas Industry Social and Environmental Research Alliance
HFS	Hydraulic Fracture Stimulation
km	Kilometre
LACA	Land Access Compensation Agreement
LWD	Logging While Drilling
NLC	Northern Land Council
m	Metres
MD	Measured Depth
ML	Megalitres
MoC	Management of Change
NRM	Natural Resource Management
NT	Northern Territory
NT EPA	Northern Territory Environmental Protection Authority
NVIS	National Vegetation Information System
Panel	Independent Scientific Panel
PL	Petroleum Lease

Acronym / Abbreviation	Description
PMST	Commonwealth Protected Matters Search Tool
PPL	Petroleum Pipeline Licence
SEAAOC	South East Asia Australia Onshore Conference
SMS	Santos Management System
SSCC	Sacred Site Clearance Certificate
TOC	Total Organic Content
TPWC Act	Territory Parks and Wildlife Conservation Act 2014
TVD	True Vertical Depth
TVDSS	True Vertical Depth referenced to sea-level (Australian Height Datum)
WOMP	Well Operations Management Plan
WoNS	Weed of National Significance
WWMP	Wastewater Management Plan

1.0 Introduction

1.1 Background

Santos proposes to undertake exploration and appraisal activities in EP 161 in 2019, 2020 and beyond. The purpose of exploration and appraisal activity is to increase our understanding of the prospectively or potential of the permit area. Our objective whenever undertaking such activity is to minimise our impact on the environment, including any activities of Traditional Owners and pastoral lessees.

Under the Petroleum (Environment) Regulations (the Regulations), interest holders in petroleum titles must prepare and submit an Environment Management Plan (EMP). Approval of an EMP is necessary for all activities that have an environmental impact or risk and is only one of several approvals required for the activity to proceed. An approved EMP is a statutory document that is enforceable.

The Code of Practice for Petroleum Activities in the Northern Territory (CoP) sets out the mandatory requirements for management plans for wastewater and spills. The CoP states that an EMP for a petroleum activity must include a Wastewater Management Plan (WWMP).

1.2 Scope

Santos proposes to undertake a Hydraulic Fracture Program in 2019 / 2020 at the Tanumbirini-1, Tanumbirini 2H and Inacumba 1/1H locations (3 wells). This WWMP is to be included in the EMP for the Hydraulic Fracturing Program.

This WWMP assesses all water and wastewater management activities which are proposed including:

- Water that has been used in or produced from petroleum wells, whether it is being re-used, recycled, treated or disposed of, and includes flowback fluid, produced water, completion fluids and well suspension fluids.
- "waste material" and material containing "contaminants" as defined in s 117AAB of the *Petroleum Act 1984* (NT)
- Wastewater meeting the definition of waste under the *Waste Management and Pollution Control Act 1998* (NT)
- Water that has been acquired or used in petroleum activities that is being disposed of (for example, unused volumes of hydraulic fracturing fluid or raw water).

Non-aqueous drilling fluids will not be used as part of the proposed activities.

This WWMP is for the Hydraulic Fracture Program at the Tanumbirini 1, Tanumbirini 2H and Inacumba 1/1H locations. This program does not include any drilling activities, and therefore does not contemplate the management of fluids generated as a part of those activities (e.g. drilling fluids). A separate EMP has been submitted for drilling, civil works and seismic activities.

1.3 Wastewater management framework

This WWMP comprises a component of a wastewater management framework.

1. Estimate the quantities and quality of water and wastewater from the petroleum activity

2. Define the methods and approaches that will be used to store, treat, and reuse water and ultimately dispose of wastewater, including what activities will be undertaken at the site of the approved petroleum activity
3. Estimate the quantities and quality of wastewater, or wastewater derived solids, that will be removed from the petroleum site
4. Describe the relevant activities, environmental risks and environmental impacts involved in a wastewater management plan (WWMP)
5. Monitor, manage and report in accordance with the WWMP

1.4 Waste management hierarchy

This WWMP has been developed in consideration of the waste management hierarchy outlined in the National Waste Policy, 2018. Where practical, waste and wastewater management activities are designed to sequentially and preferentially avoid, reduce, reuse, recycle and treat before disposing of waste and wastewater. This is described in Section 2.4.3.

2.0 Wastewater Management

2.1 Activity description

This section contains a description of the activities that will generate waste and wastewater, including any activities that may generate wastewater and any other waste that is proposed to be handled, stored or transported away from the area in which the activity is approved to be carried out.

Activities that will generate waste are summarised in Table 2-1 and described in the following sections.

Table 2-1 Waste generating activities

Activity – waste source	Waste Type
Domestic activity (camp and offices)	Putrescible and municipal waste
	Recyclables (glass and cans)
	Grey water (laundry, showers, sink wastes, etc.)
	Treated sewage effluent
	Toilet waste (port-a-loos)
Ancillary activities to Hydraulic Fracturing	Chemical bags and cardboard packaging materials
	Scrap metals
	Used chemical containers and fuel drums
	Chemical wastes
	Timber pallets (skids)
	Vehicle tyres
	Oily rags, filters
Hydraulic Fracture Stimulation	Flowback fluid and produced water

2.1.1 Domestic activities

Sewage management practices at all camps will consist of the use of port-a-loos and a fully self-contained sewage treatment plant (STP). Sewage from port-a-loos will be transported offsite by a waste management contractor.

The STP will be furnished with an irrigation sprinkler system to manage sewage and grey water wastes. All waste water will be disposed of in accordance with the Public and Environmental Health Regulation 2018. Discharge from the camp will be treated to achieve the specifications provided in the Northern Territory's Code of Practice for On-site Wastewater Management. Treated effluent will be sprayed 50-100m away from the camp at a location that will be well away from any place from which it is reasonably likely to enter any waters, and to minimise spray drift and ponding. Fencing will be installed around the irrigation area.

Wastepaper, cardboard and food scraps are disposed of into sealed bins set up adjacent to the camp area. The sealed bins will be transported for disposal of waste to a licensed landfill. Recyclable materials will be managed on site and transported to an approved local waste depot facility (likely in Katherine or Darwin).

2.1.2 Ancillary activities to hydraulic fracturing

All waste streams from ancillary activities will be collected and stored on site. Waste will be transported for disposal or recycling as described in Section 2.4.

2.1.3 Hydraulic Fracture Stimulation Process

Santos proposes to undertake a Hydraulic Fracture Program at the Tanumbirini 1, Tanumbirini 2H and the Inacumba 1/1H locations (3 wells).

2.1.3.1 Hydraulic Fracture Stimulation

Hydraulic Fracture Stimulation (HFS) involves the injection of hydraulic fracturing fluids at high pressure into a cased wellbore, it is usually conducted over a number of intervals or stages along the hydrocarbon bearing zones of the well.

Stimulation fluids comprise water based fluids injected into a well as part of a well stimulation operation. Hydraulic stimulation fluid contains predominantly water and proppant (sand or ceramic) which generally comprises more than 98% of the volume. Minor volumes of additives such as gels, friction reducers, crosslinkers, breakers and surfactants make up the remainder of the stimulation fluid. . Additives are selected for their ability to;

- improve the effectiveness of the stimulation process, i.e. to increase the productivity of the well,
- to ensure proppant/sand can be transported into the created fractures, and
- to ensure that once the proppant/sand is placed in the fracture, the stimulation fluid can be flowed back to surface.

Hydraulic fracture stimulation occurs in stages. At the completion of each stage (there can be multiple) the previous stage is isolated while the next stage is perforated and then fractured stimulated.

2.1.3.2 Well flowback

A well and the adjacent formation which has been fracture stimulated is highly pressurised following the completion of all fracture stimulation stages. The pressure is sufficient to force fluid from the well to the surrounding formation. Once the pressure from the fracture stimulation process has been depleted, pressure stored within the formation will continue to force fluid back to surface from the well. The fluid recovered in this way is called flowback fluid.

Flowback fluid is a mixture of hydraulic fracturing fluid and formation fluid that is controlled and allowed to flow from the well following hydraulic fracturing. The flowback stage continues until sufficient fracturing fluid is removed for the well to sustain flow unassisted. The well will then typically be connected to a flowline to continue the clean-up process. A separator separates flowback fluid and hydrocarbons.

The rate and duration of flowback fluid recovery depends on many factors. The flowback period of wastewater may last as little one week, but may take significantly longer. All flowback fluids will be stored and managed in accordance with requirements of the CoP, and as stipulated by an approved WWMP.

2.1.3.3 Produced Water

Produced water means naturally occurring water that is extracted from the geological formation following hydraulic fracturing. The proportion of recovered water that comprises produced water increases as the rate of flowback fluid recovery declines (see Figure 1). Water quality monitoring of flowback fluid can determine when the recovered water is likely to comprise predominantly produced water.

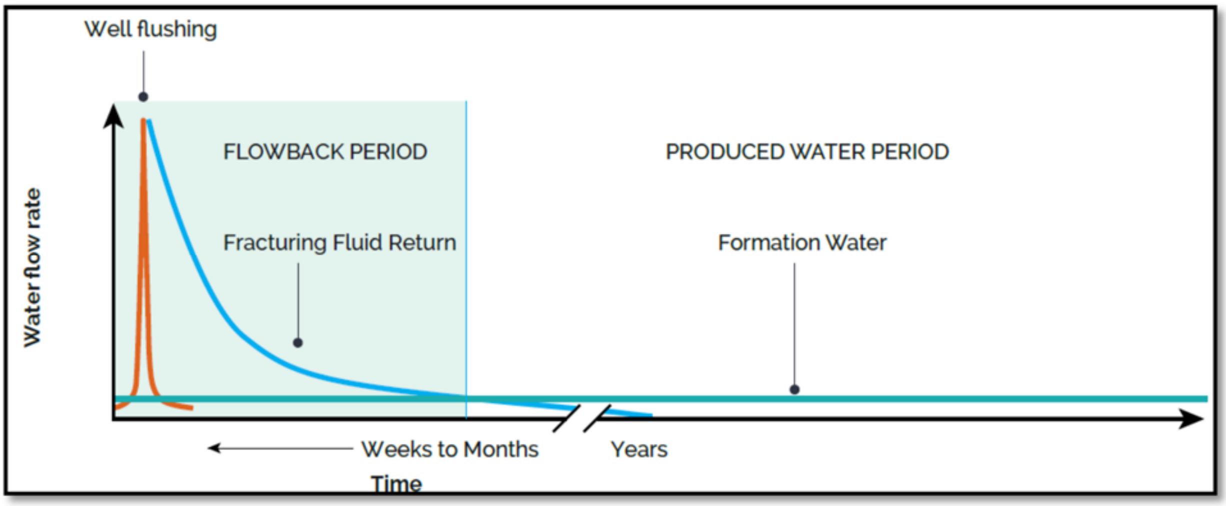


Figure 2-1 The difference between Flowback and Produced water

2.2 Waste characteristics

This section characterises the anticipated wastewater streams that will be generated, including chemical characteristics and volumes of each.

Table 2-2 provides a summary of the anticipated wastewater characteristics. Further detail is provided for hydraulic stimulation fluid and flowback fluid.

Table 2-2 Anticipated wastewater characteristics

Waste	Estimated volume	Chemical characteristic	Management method
Domestic waste – putrescible, municipal and recyclable	Less than 200m^3	Potentially hazardous to non-hazardous	Designated collection bins with transport off-site by licensed contractor
Domestic wastewater – grey water and treated sewage effluent	Less than 720m^3	Non-hazardous	Reticulated collection, on-site treatment and disposal via irrigation
Domestic wastewater – port-a-loo toilets	Less than 100m^3	Potentially hazardous	Collection and storage on-site, disposal off-site by licensed contractor
Ancillary activities to HFS	Less than 100m^3	Hazardous to non-hazardous	Collection and storage on-site, and transport off-site by licensed contractor
Hydraulic stimulation fluid	See Section 2.2.1		Reused where possible. Storage in monitored, lined and bunded tanks.

Waste	Estimated volume	Chemical characteristic	Management method
Flowback fluid	See Section 2.2.2.		Containment and storage in monitored, lined and bunded enclosed tanks, and treatment (evaporation) in lined open ponds.

2.2.1 Hydraulic fracture stimulation fluids

2.2.1.1 Volumes

Each horizontal well is expected to require a 25-stage fracture stimulation process. Based on 25 stages, estimates are that each well requires up to 32.5 ML of hydraulic stimulation fluid in total. An upper estimate of the total volume of hydraulic fracture stimulation fluids is conservatively therefore 80 - 100 ML.

2.2.1.2 Chemical characteristics

In hydraulic stimulation treatments, water accounts for more than 90% of the mixture and proppant (sand or ceramic) accounts for between 5-9%. Chemical additives generally account for less than 1-2% of the mixture and assist in carrying and dispersing the proppant and/or sand in the low permeability rock, and then allowing the fracturing fluid to be returned to surface once the proppant/sand is placed.

The stimulation process involves pumping water, a specific blend of chemical additives and a propping agent such as sand or ceramic beads down the well at sufficient pressure to create a fracture in the target formation. Proppant keeps the fractures open once the pump pressure is released, and fracturing fluid has been flowed back to surface. This increases the effective permeability of the formation and therefore improves the gas production potential of a well, ultimately reducing the number of wells required to produce hydrocarbons from the formation.

Additives used have various purposes such as:

- Viscosity – gelling agents (natural plant based) are added to the water to provide viscosity to enable the proppant material to be transported down the well and into the created fractures.
- Friction reduction – to reduce the force required to pump the fluid, making the fluid more slippery and easier to pump at high pressures and high rates required to create the fracture network.
- Biocide – added to treat the water to ensure that there are no microbes or organisms present that will affect the gelling agents and to ensure they will not enter and affect the reservoir.
- Scale and corrosion – scale and corrosion inhibitors are added to prevent deposition of mineral scales and to prevent corrosion of the primary wellbore barrier (i.e. the steel casing).
- Surface tension – surfactants or surface tension modifiers are added to assist the flowback of fluids from the formation

It is not necessary to use all of these additives for every stimulation. Specific additives are selected during evaluation of downhole conditions, depending upon the particular requirements.

All chemical additives used in Australia must be approved for use by the Commonwealth Government, Department of Health and listed on the Australian Inventory of Chemical Substances which is maintained under the National Industrial Chemicals Notification and Assessment Scheme.

No hydraulic fracturing fluid additives that are used in the process contain compounds of benzene, toluene, ethylbenzene or xylene (BTEX).

The Material Safety Data Sheets for all the chemicals will be provided as part of the Hydraulic Fracture Program Applications to the DENR and DPIR.

Monitoring of stimulation fluid is detailed in Section 2.7.2 of this WWMP.

A detailed Chemical Risk Assessment (CRA) for all proposed hydraulic fracturing fluid is provided in Appendix A of the EMP. The hydraulic fracturing fluid systems assessed in the CRA include chemicals proposed by Halliburton as part of their Coil Tubing Hydraulic Fracturing System (Coil Chemicals) and Standard Hydraulic Fracturing System (Hydraulic Fracturing Chemicals).

2.2.2 Flowback fluid

2.2.2.1 Volumes

It is anticipated that each well will produce approximately 5-20ML of flowback fluid.

2.2.2.2 Chemical characteristics

Flowback fluid will comprise a blend of formation water and hydraulic fracture stimulation fluid (see Section 2.1.3). The blend will be dynamic in time. The characteristics of the fluid will approximate the water quality of the reservoir as the rate of recovered fracture stimulation fluid decreases.

A considerable volume of the injected stimulation fluid is expected to be recovered as flowback fluid. Studies performed by the US EPA (US Environment Protection Agency (EPA), 2004) indicated that approximately 60% of the fluids are recovered in the first three weeks, and total recovery back to surface was estimated to be from 68–82% noting that the proppant remains in place. However the rate of recovery, and total percentage recovery is likely to be variable.

Hydraulic fracturing fluid additives will not contain benzene, toluene, ethylbenzene or xylene (BTEX) in accordance with the Code of Practice. However it is feasible that flowback fluid may contain organic compounds which are found naturally in the target formation. Recovery of some natural gas liquids from the shale production zone may be expected and is managed by onsite separators which can effectively segregate hydrocarbons and water. This EMP is in support of an exploration project and the results of this exploration project including the environmental monitoring program are designed to support the characterisation formation fluids (including flowback).

Valid gas sample analysis to date acquired from well-test separators while flowing from the Velkerri Formation indicate negligible presence of the aromatic compounds associated with BTEX (C_6H_6 C_7H_8 C_8H_{10}). 0.003mol% at Shenandoah-1A and 0mol% at Wyworrie-1.

An assessment of Naturally Occurring Radioactive Material (NORM's) was undertaken by Origin during the Amungee NW-1H well drilling and testing in 2016. The observed radionuclide level within flowback and gas samples observed from Amungee NW-1H are at the lower end of those observed in the USA shale developments (Kibble et al. 2013) and unlikely to pose a risk. To put this in context, for the flowback to reach the regulatory limit of 1 mSv/year, a person would have to consume greater than 80 litres of flowback fluid.

The results are expected to be similar to the Tanumbirini 1/2H and Inacumba 1/1H locations.

Monitoring of flowback fluid is proposed in Section 2.7.3. The results of the sampling and analysis of the flowback fluid will inform re-use, recycling and disposal options.

A detailed Chemical Risk Assessment (CRA) for all proposed hydraulic fracturing fluid is provided in Appendix A of the EMP. The hydraulic fracturing fluid systems assessed in the CRA include chemicals proposed by Halliburton as part of their Coil Tubing Hydraulic Fracturing System (Coil

Chemicals) and Standard Hydraulic Fracturing System (Hydraulic Fracturing Chemicals). This CRA includes an assessment of the treatment and disposal of flowback fluid.

2.3 Wastewater storage and rainfall

The hydraulic fracture program is anticipated to begin in October, 2019. All flowback fluids will be stored in accordance with the CoP for as long as it takes to treat the fluid prior to re-use or disposal. The determination of significant rainfall events and calculations of tank/pond freeboard are detailed below.

This section contains:

- *estimates for the 1 in 1000 average recurrence interval (ARI) rainfall rate using Australian Rainfall and Runoff methodologies for the critical period during which there would be greatest risk of overtopping of any structures holding wastewater which are not enclosed*
- *a minimum freeboard for treatment infrastructure to accommodate total rainfall anticipated (based on 1:1000 year average recurrence interval rainfall estimates for the period that treatment infrastructure contains water*
- *a plan to transfer produced water and flowback fluid into above ground enclosed tanks at least 8 hours in advance of any predicted significant rainfall event as specifically defined based on local weather conditions and other site specific risks*
- *a strategy (including environmental performance standards and measurement criteria) for detecting and responding to predicted significant rainfall events, with a focus on wet season*

2.3.1 Estimate of ARI rainfall

Appendix A provides the methodology which was used to determine the 1 in 1000 year average recurrence interval (ARI) for rainfall over a 7-days period and throughout the entire duration of the wet season at the location of the proposed petroleum activities. The 1 in 1000 year ARI is assumed to be equivalent to an annual exceedance probability (AEP) of 0.1%. Table 2-3 below summarises the findings.

Table 2-3 The 1 in 1000 (0.1%) year AEP for rainfall at the location of the proposed petroleum activities

0.1% AEP Rainfall period	Rainfall (mm)
7-day	654
Nov-May inclusive	1,168

2.3.2 Minimum freeboard

A minimum of 1.5m freeboard will be maintained in all open tanks used to treat flowback fluid throughout the wet season. This is conservative, given the entire wet-season 0.1% AEP is 1.168 m. This adequately considers the potential overtopping risk due to potential wind and wave action. The available freeboard will be monitored as referenced in Section 2.7.

The freeboard requirements will be clearly marked on each of the tanks as the Maximum Water Level (MWL).

2.3.3 Significant Rainfall Events

Treatment of produced water or flowback fluid in open tanks requires the water to be able to be transferred to above ground enclosed storage tanks at least 8 hours in advance of a predicted significant rainfall event.

In this context, a significant rainfall event is defined as a rainfall forecast published by the BOM which is greater than 300mm of total rainfall is predicted over a 4-day period.

2.3.4 Detection and response strategy

A significant rainfall event will be detected by tracking the predicted for a 7 day period that commences at least 5 days from the day of forecast. Santos will receive forecast rainfall directly from BOM.

In response to detection, Santos would 'make-ready' to begin the transfer of all water into the closed tank(s) prior to the onset on of the forecast significant rainfall event and transfer may commence. All waste water will be transferred prior to the onset of the forecast initial 7-day significant event.

BOM rainfall forecast may be reviewed each day. The transfer of waste water is the forecast no long predicts a significant rainfall event. The day after initial detection, the forecast will be reviewed.

This strategy intends to meet the requirement to transfer the produced water and flowback fluid into above-ground enclosed tanks at least 8 hours in advance of a predicted significant rainfall event.

The monitoring of rainfall forecasting will be the responsibility of the Water Management contractor, the flowback fluids transfer procedure will form part of the critical procedures associated with the hydraulic fracture and flowback testing program.

2.4 Waste management methods and locations

This section contains a proposed method and location of water and wastewater storage, transportation, treatment disposal and re-use as part of the proposed activity, with reference to any requirements mandated by the COP. It will demonstrate how fluid levels will be managed to maximise the rate of evaporation relative to the volume of fluid held in the treatment infrastructure.

2.4.1 Proposed methods

A broad overview of the waste management methods are described in Section 2.1. Disposal options have taken into account the results of the project risk assessment, section 6 of the EMP.

Control measures will be implemented to minimise the risk of interactions of all stored waste with wildlife, stock and human receptors. Controls measures will comprise fencing, signage and fauna-proof containment as necessary.

Table 2-4 Waste generating activities and management methods

Activity – waste source	Waste type	Management and disposal method
Domestic activity (camp and offices)	Putrescible and municipal waste	Collected at campsite for disposal to licenced landfill
	Recyclables (glass and cans)	Collected at campsite for deposit at licenced recycling facilities

Activity – waste source	Waste type	Management and disposal method
	Grey water (laundry, showers, sink wastes, etc.) and treated sewage effluent	Grey water captured and piped to a treatment system that meet the NT Code of Practice for Small On-site Sewage, then piped to an irrigation area.
	Toilet waste (port-a-loos)	Toilet waste will be captured and transported offsite for recycling or disposal.
Ancillary activities to Hydraulic Fracture Stimulation	Chemical bags and cardboard packaging materials	Compacted and collected at rig site for disposal to licenced landfill
	Scrap metals	Collected in designated skip for transport to licenced recycling facility
	Used chemical and fuel drums	Collected in designated skip for recycling and re-use
	Chemical wastes	Collected in approved containers for disposal at licenced landfill
	Timber pallets (skids)	Collected at site and recycled or disposed of at licenced landfill
	Vehicle tyres	Shredded and disposed to licenced landfill
	Oily rags, filters	Collected in suitable containers for disposal at licenced landfill
Hydraulic Fracture Stimulation	Flowback Fluid and Produced Water	Collected and stored in enclosed double-lined, above-ground storage tanks. Evaporation used to treat the waste volume whilst in double-lined, above-ground open storage tanks. Open storage tanks to be used to treat the fluids via evaporation to reduce the waste volume prior to disposal. The total stored volume will be transferred to enclosed storage tanks if significant rainfall is forecast. Once the volume has sufficiently reduced by evaporation the fluid will be transferred to enclosed storage or collected in a vac truck for offsite disposal at licenced waste treatment facility (in accordance with NT Waste Management and Pollution Control Act and Queensland Environmental Protection Act 1994). Disposal method to be determined following waste characterisation and risk assessment. No recycling or re-use of produced water or flowback fluid is proposed.

2.4.1.1 Flowback fluid and produced water storage

Flowback fluids will be managed onsite with the aim to contain all fluids and chemicals and avoid and manage the risk of interaction with soil, soil substrate, surface water and groundwater. The following management controls will be in place for the duration of the hydraulic fracturing program;

- Wastewater will be stored in enclosed, above-ground storage tanks that:

  - meet secondary containment as set out in Section A.3.8(g) of the CoP
  - limit the ingress of rainwater into the tank to an amount that is ALARP and acceptable
  - where connected together, be designed and operated to prevent the uncontrolled discharge of multiple tanks should one fail
  - be designed to prevent overtopping
  - be designed and constructed to any standards that apply in the NT for the type of structure and be able to withstand bushfires and wind loading conditions reasonably expected in the area
  - be designed to reduce the risk of a build-up of explosive gases to a level that is ALARP and acceptable
- Secondary containment will comprise:
  - individual secondary containment (i.e. double-lined or double-walled storage tanks) and so sufficient capacity to hold 100% of the volume of the largest container stored in the area plus 10% is not required
  - permeability able to contain materials or waste until it can be removed or treated
  - provide for separation of clean and dirty water
  - be compatible with the material or waste stored or used within the containment
  - be resistant to physical, chemical and other failure during handling, installation and use
  - be maintained and in good order at all times
- Ponds and tanks will be double lined with built-in leak detection:
  - shall be inspected weekly, unless being operated through the wet season (Nov-March inclusive) during which it must be monitored daily. Repairs should be carried out as soon as possible
  - materials that escape primary containment or are otherwise spilled onto secondary containment shall be removed as soon as possible
  - inspection reports and maintenance records of secondary containment shall be kept.

2.4.1.2 Treatment in open tanks

The risk of overtopping will be managed by:

- Maintaining freeboard as described in Section 2.3.2
- Monitoring for significant rainfall events (defined in Section 2.3.3) and transferring to enclosed tanks as described in Section 2.3.4.

To maximise the rate of evaporation relative to the volume of fluid held in the open tanks, fluid levels will maintained below the freeboard level and periodically circulated between open and enclosed storage. Evaporation rates will be maximised by ensuring there is sufficient cycling between open and enclosed tanks to maintain a small discrepancy between the salinity of water held in open storage and enclosed storage.

2.4.1.3 Flowback fluid and produced water disposal

Results from the monitoring of flowback fluid and produced water (refer to Section 2.7) will be used to validate any proposed wastewater treatment and disposal options.

A decision on disposal of the residual flowback fluid and produced water will be made on the advice of a licenced waste management service provider. Treatment and/or disposal will be at a licenced facility (see Table 2-5 Waste Types and Waste Disposal Locations).

Residual produced water and flowback fluids will be transported to a licenced interstate disposal facility with the appropriate interstate waste transport consignment authority as per the National Environmental Protection (Movement of Controlled Waste between States and Territories) Measure 1998 (NEPM) as implemented under the NT Waste Management and Pollution Control Act.

When the tanks are decommissioned the associated residual solids, brines and liners are removed and disposed of at an appropriately licensed waste disposal facility by a licenced contractor as per NT Waste Management and Pollution Control Act.

After fluid is removed from tanks, and no further flowback fluid or produced water is required to be managed, the above-ground storage tanks will be decommissioned, deconstructed and moved off-site.

2.4.2 Proposed locations

The EMP for the proposed activities provides a layout of the proposed Infrastructure for each well site (refer to Figure 3-2 and Figure 3-3 of the EMP). These layouts show waste storage locations as follows:

- Dam – correspond to a lined earth-bund structure that will be used to store abstracted groundwater
- Rig campsite – which will be the area that the grey water is reticulated and all other camp wastes are stored
- Laydown area – which will be the area that waste from Drilling and Completion activities will be stored
- Well lease area – area in which above-ground tanks will be located and used to store fluid.
- Water tank pads – these are engineered pads that have been constructed to store above ground flowback fluid storage.

Proposed waste disposal locations are provided in Table 2-5.

Table 2-5 Waste Types and Waste Disposal Locations

Type of Waste	Disposal Location
General and food	Katherine or Darwin, NT
Empty IBCs	Katherine or Darwin, NT
Metal and plastic drums	Katherine or Darwin, NT
Waste material	Katherine or Darwin, NT
Batteries and tyres	Katherine or Darwin, NT
Residual chemicals	Mt Isa or Townsville, Qld
Flowback Fluids and Produced Water	On-site treatment to reduce waste volume, offsite disposal via licenced facility in Mt Isa or Townsville, Qld
Listed Waste	Any waste prescribed wastes under the Waste Management and Pollution Control Act as specified as a listed waste by the NT EPA as found at https://ntepa.nt.gov.au/waste-pollution/approvals-licences/listed-waste, will be disposed of in accordance with the regulations and by a company licensed to handle and dispose of this waste.

2.4.3 Management of wildlife, stock and human interaction

This section provides an implementation plan of control measures to prevent the interactions of wildlife, stock, and human receptors with wastewater and a program for monitoring and reporting on the effectiveness of mitigation measures for avoiding wildlife, stock and human interactions

2.4.3.1 Control Measures

Control measures to prevent the interactions of wildlife, stock, and human receptors with wastewater are detailed in Table 6-1 of the EMP and include, amongst other things:

- Fauna ladders will be installed at all groundwater storage ponds
- Fauna ladders and / or bird islands will be installed at the wastewater treatment tanks
- Tank pads and treatment tanks will be fence and signposted.
- Treatment tanks are high enough to prevent interaction with non-flying fauna species

2.4.3.2 Program for Monitoring and Reporting

Daily checks of tanks/ponds will be conducted during the program and at times specified in Table 2-5 below.

Table 2-6 Fauna Interaction Monitoring

Locations	Monitoring Methodology	Frequency	Reporting
Inside Wastewater Tanks	Visual inspection water tanks for bird carcasses. Visual inspection of the fauna ladder/ bird islands present. Inspection of fauna utilising the tank pad area. Including photographs of bird using the tanks to perch	Daily during operations	Reported into the Daily report and in accordance the reporting requirements in Petroleum (Environment) Regulations.
Inside Wastewater Tanks	Inspect the tanks at completion for carcasses present during tank emptying	During final decommissioning	Contents of tanks during tank emptying reported in the Rehabilitation / Decommissioning report
Areas on and adjacent to leasepad	Detailed fauna opportunistic observation surveys and photos to be taken around wastewater tanks. Survey to be conducted by a suitably qualified ecologist	Annually Conducted in conjunction with post-wet season weed surveys	Annual ecological monitoring report

2.4.4 Availability and appropriateness of approach

All approaches outlined in the sections above are available and appropriate to manage the risk, and in accordance with the CoP.

2.5 Waste minimisation strategies

This section contains strategies to minimise or reduce the volume of wastewater that will be disposed of off-site, and the expected quality and quantity of water and wastewater that will be treated and re-used within the petroleum activity

Table 2-7 summarises the methods that will be used to minimise waste in accordance with the waste management hierarchy.

Table 2-7 Hydraulic Fracture Stimulation waste streams – waste management hierarchy considerations

Waste Stream	Avoid	Reduce	Reuse	Recycle	Treat	Dispose
Flowback fluids and produced water	Cannot avoid	Recycling of fluids reduces consumption of additives and therefore the production of waste.	No re-use of fluids is proposed.	No recycling of fluids is proposed.	Maximise evaporation rates to reduce volume	Remaining fluid will be assessed by licenced waste management service provider. It will be transferred to a 3rd party process facility for further treatment and/or disposal in accordance with NT Waste Management and Pollution Control Act.

2.6 Risk assessment

An assessment of environmental impacts and environmental risks posed by the hydraulic fracture program has been carried out. For completeness and consistency with the environmental risk assessment of all activities, this is presented in Section 6 of the EMP.

2.7 Monitoring plan

This section contains a monitoring plan that:

- *Outlines the sampling locations, frequency, proposed analytical methods and analytical detection limits, and any quality assurance and quality control measures that will be implemented*
- *Reflects all monitoring requirements mandated by the COP and the EMP, as well as any monitoring that is determined to be necessary as part of the risk assessment*
- *Requires all field measurements and sampling to be undertaken by suitably qualified personnel and to utilise equipment that is suitably maintained, laboratory checked and calibrated*
- *Requires all laboratory analyses to be conducted at a National Association of Testing Authorities (NATA) accredited lab, where possible.*

2.7.1 General water monitoring

The quality and quantity of all water stored will be monitored.

2.7.1.1 Quantity

Volume of water that is abstracted from the water bore will be measured using flowmeters. This will be recorded weekly during bore operations. Santos intends to extract water from the three existing water bores (RN40930, RN40931and RN38580), and any other bores which it may be authorised to take water from in accordance with the NT Water Act (1992).

Extracted groundwater will be pumped directly from the water bores and stored in fenced and lined ponds. Fluid levels in storage dams and tanks of abstracted groundwater will be monitored once a month. This provides a measure of the stored quantity of water.

2.7.1.2 Quality

Water quality of abstracted groundwater stored in tanks will be sampled monthly. The suite will be tested as per Table 2-8. Testing will comprise grab samples from the tank, or a sample of water pumped from the storage tank. Sampling will continue until the fracture stimulation activities are complete.

2.7.2 Hydraulic fracturing fluid monitoring

The quality and quantity of stimulation fluid will be recorded.

A hydraulic fracturing fluid monitoring program will be established and implemented to characterise and record the quality and quantity of the fluid used to hydraulic fracture a well. The monitoring programme meets Section B.4.13.2(c) of the CoP.

2.7.2.1 Quantity

The total volume of hydraulic fracture stimulation fluid that is pumped will be recorded for each stage (where a stage in this context means all fluids pumped at a particular depth interval).

2.7.2.2 Quality

A characterisation sample of the hydraulic fracture stimulation fluid will be taken that is considered representative of the fluid system used in each well. Analyses will not be repeated if the same water source and fluid system is used for multiple stages within the same well. If the fluid system is changed (i.e. Coil Tube vs Standard fluid) then an additional sample will be collected. The sample will be tested for the suite shown in Table 2-9.

Records of the concentrations of chemical additives or other substances used to make up the stimulation fluid will be recorded. Laboratory records of the make-up water and stimulation fluid characterisation monitoring will be recorded as per Table 2.8.

2.7.3 Flowback fluid monitoring

For hydraulic fracturing, a flowback fluid monitoring program will characterise the quality and quantity of flowback fluid generated during flowback activities.

The monitoring program characterises flowback fluid quality through the following measures:

- *Continuous monitoring (sampling frequency at least once per 24 hours) of EC, pH and temperature*
- *Monitoring at least weekly for a duration long enough that the quality of the flowback fluid is sufficiently stabilised against criteria described in the WWMP, and tested for analytes listed in Section C.8 of the CoP.*
- *Monitoring of the flowback fluid storage, as required by section C.5.5 of the CoP*

The monitoring program will measure flowback fluid volume by recording the cumulative flowback fluid volume for each well at one month, 3 month, 6 month and 12 months after flowback has commenced.

2.7.3.1 Quantity

The cumulative flowback fluid volume will be monitored by use of a flow meter located on the discharge line between the well and the flowback storage facilities. The cumulative volume will be recorded at 3 months, 6 months and 12 months after flowback has commenced, +/- 5 days (only while flowback is occurring).

2.7.3.2 Quality

The monitoring of flowback fluid quality will comprise:

- Continuous monitoring (sampling frequency of at least once per 24 hours) of electrical conductivity, pH and temperature of water in the flow line between the well and the flowback storage facilities.
- Weekly monitoring until the quality of the flowback fluid has sufficiently stabilised (criteria described below), tested for the analytes listed in Table 3-2, of water in the flow line between the well and the flowback storage facilities.
- Field measurements of electrical conductivity will be used to determine when the quality of the flowback fluid has sufficiently stabilised. Stability is deemed to comprise a change of less than 5% over 3 consecutive weeks (exclusive of limit of detection rounding, and method accuracy).
- Monitoring of the flowback fluid in storage, as defined in Section 2.7.4.

2.7.4 Produced water and flowback fluid storages

The quality and quantity of flowback fluids and produced water will be recorded.

Stored volume and available freeboard for all produced water and flowback fluid storage facilities will be monitored at least weekly, unless being operated during the wet season when they will be monitored daily.

A sample from all produced water and flowback fluid storages will be taken at least once every 6 months and tested for the analytes in Table 3-2.

The volume of water and wastewater into each tank will be tracked.

The following section provides the basis of a flowback fluid monitoring program.

Quantity

The stored volume and available freeboard of all flowback fluid and produced water storage facilities will be recorded at least weekly from April to October inclusive (dry season), and at least daily from November to March inclusive (wet season).

Quality

Monitoring of the flowback fluid storage at least once every 6 months, tested for analytes listed in Table 3-2.

2.7.5 Monitoring of disposal to licenced facility

The volume of water and wastewater removed from site and its destination, including the licence number of any licenced waste transporter, will be recorded.

Records regarding the transfer of waste to licenced facilities will be maintained in accordance with requirements under the NT Waste Management and Pollution Control Act.

2.7.6 Quality assurance and quality control measures

All field measurements and environmental sampling will be undertaken by suitably qualified personnel.

All monitoring equipment will be suitably maintained and calibrated prior to use, as per manufacturer's instructions.

All samples shall be collected using suitable sample containers, preservation methods and chains of custody prior to receipt by analytical laboratories. Holding times will be met, where feasible.

All laboratory analyses will be conducted at a National Association of Testing Authorities (NATA) accredited lab, where feasible.

2.8 Reporting

In accordance with Part 3A of the Petroleum (Environment) regulations, Santos will give the Minister a report about flowback fluid. The information contained within the report and the timing of the report is provided in detail in Section 8.0 of the EMP.

2.8.1 Water and wastewater tracking and reporting requirements

The movement of water and wastewater will be tracked and reported on in accordance with the Code of Practice. All water and wastewater tracking will include:

- volumes of produced water and flowback fluid from each well;
- volumes of water transferred into each tank;
- estimates for evaporation rates from each tank;
- volumes of water planned to be, and ultimately, reused in petroleum operations including drilling and hydraulic fracturing;
- volumes of water and wastewater used for other purposes including dust suppression and construction water;
- volumes of water and wastewater removed from site and its destination (whether by vehicle or pipeline) including details of the licence number of the any licensed waste transporters; and
- volumes of any spills of water or wastewater.

Wastewater tracking will be documented in an auditable chain of custody system. Wastewater tracking must be in accordance with other legislative requirements such as those imposed under the *Waste Management and Pollution Control Act 1998, Radiation Protection Act 2004, Work Health and Safety (National Uniform Legislation) Act 2011* and the *Water Act 1992*. Wastewater tracking documentation must be reported to the Minister at least annually in the annual report.

Table 2-8 Suite of analysis for testing of stored groundwater

Analyte	ALS Method Code	Limit of reporting	Units
Electrical Conductivity (EC) (measured in field)	EA010-P	1	µS/cm
Total Dissolved Solids (TDS)	EA015H	10	mg/L
Total Suspended Solids (TSS)	EA025H	5	mg/L
pH (measured in field, and in lab)	EA05-P	0.01	pH Units
Sulfate (SO_4^{-2})	NT-2A	1	mg/L
Chloride (Cl^-)	NT-2A	1	mg/L
Carbonate (CO_3^{-2})	NT-2A	1	mg/L
Bicarbonate (HCO_3^-) (as CaCO3 equivalent)	NT-2A	1	mg/L
Bicarbonate Alkalinity (as CaCO3 equivalent)	NT-2A	1	mg/L
Hydroxide Alkalinity (as CaCO3 equivalent)	NT-2A	1	mg/L
Total Alkalinity (as CaCO3 equivalent)	NT-2A	1	mg/L
Nitrite (NO_2^-)	NT-8A	0.01	mg/L
Nitrate (NO_3^-)		0.01	mg/L
Fluoride (F^-)	NT-2A	0.1	mg/L
Sodium (Na^+)	NT-1B	1	mg/L
Magnesium (Mg^{2+})		1	mg/L
Potassium (K^+)		1	mg/L
Calcium (Ca^{2+})		1	mg/L
Arsenic	W-3, W-3T, EG020F, EG020T	0.001	mg/L
Barium		0.001	mg/L
Boron		0.001	mg/L
Cadmium		0.0001	mg/L
Chromium		0.001	mg/L
Lithium		0.001	mg/L
Copper		0.001	mg/L
Iron		0.05	mg/L
Lead		0.001	mg/L
Manganese		0.001	mg/L
Mercury		0.0001	mg/L
Selenium		0.001	mg/L
Silica		0.1	mg/L
Silver		0.001	mg/L
Strontium		0.001	mg/L
Zinc		0.001	mg/L

Table 2-9 Suite of analyses for testing of Wastewater

Group	Analyte	Limit of reporting	Units
Physio-chemical	Dissolved oxygen (DO) measured in situ	0.1	mg/L
	Electrical Conductivity (EC) measured in situ and lab	1	µS/cm
	Total Dissolved Solids (TDS)	10	mg/L
	Total Suspended Solids (TSS)	5	mg/L
	pH measured in situ and in lab	0.01	
	Temperature measured in situ	0.1	°C
Nutrients	Nitrate	0.01	% saturation and mg/L
	Nitrite	0.01	
	Total Nitrogen	0.1	
	Total Kjeldahl Nitrogen	0.1	
	Ammonia	0.01	
	Reactive Phosphorus	0.01	
	Total Phosphorus	0.01	
	Sulfate (SO_4^{-2})	1	mg/L
	Chloride (Cl^-)	1	mg/L
	Carbonate (CO_3^{-2})	1	mg/L
	Bicarbonate (HCO_3^-) as CaCO3 equivalent	1	mg/L
	Bicarbonate Alkalinity as CaCO3 equivalent	1	mg/L
	Hydroxide Alkalinity as CaCO3 equivalent	1	mg/L
	Total Alkalinity as CaCO3 equivalent	1	mg/L
	Nitrite (NO_2^-)	0.01	mg/L
	Nitrate (NO_3^-)	0.01	mg/L
	Fluoride (F^-)	0.1	mg/L
	Bromide (Br^-)	0.01	mg/L
	Total Cyanide	0.004	mg/L
Major cations	Sodium (Na^+)	1	mg/L
	Magnesium (Mg^{2+})	1	mg/L
	Potassium (K^+)	1	mg/L
	Calcium (Ca^{2+})	1	mg/L
Metals and metalloids	Aluminium	0.01	mg/L
	Antimony	0.001	mg/L
	Arsenic	0.001	mg/L
	Barium	0.001	mg/L
	Beryllium	0.001	mg/L
	Boron	0.001	mg/L
	Cadmium	0.0001	mg/L
	Chromium	0.001	mg/L
	Cobalt	0.001	mg/L
	Copper	0.001	mg/L
	Iron	0.05	mg/L
	Lead	0.001	mg/L
	Manganese	0.001	mg/L
	Mercury	0.0001	mg/L

Group	Analyte	Limit of reporting	Units
	Molybdenum	0.001	mg/L
	Nickel	0.001	mg/L
	Selenium	0.001	mg/L
	Silica	0.1	mg/L
	Silver	0.001	mg/L
	Strontium	0.001	mg/L
	Thorium	0.001	mg/L
	Tin	0.001	mg/L
	Uranium	0.001	mg/L
	Vanadium	0.05	mg/L
	Zinc	0.001	mg/L
	Other radionuclides and gross alpha, beta, and gamma radiation	0.05-0.1	Bq/L
BTEX	Benzene	0.001	mg/L
	Toluene	0.001	mg/L
	Ethylbenzene	0.001	mg/L
	M and p Xylene	0.001	mg/L
	o Xylene	0.001	mg/L
	Total Xylenes	0.002	mg/L
TRHs	TRH C_6 - C_{10}	0.02	mg/L
	TRH C_6 - C_{10} less BTEX	0.02	mg/L
	TRH >C_{10} - C_{16}	0.02	mg/L
	TRH >C_{10} - C_{16} less Naphthalene	0.02	mg/L
	TRH >C_{16} - C_{34}	0.01	mg/L
	TRH >C_{34} - C_{40}	0.01	mg/L
	Total TRH C_6 - C_{40}	0.01	mg/L
PAHs	3-Methylcholanthrene	0.001	mg/L
	7, 12- Dimethylbenz(a)anthracene	0.001	mg/L
	Acenaphthene	0.001	mg/L
	Acenaphthylene	0.001	mg/L
	Anthracene	0.001	mg/L
	Benzo (a) pyrene	0.001	mg/L
	Benzo (b) fluoranthene	0.001	mg/L
	Benzo (ghi) perylene	0.001	mg/L
	Benzo (k) fluoranthene	0.001	mg/L
	Benzo (a) anthracene	0.001	mg/L
	Chrysene	0.001	mg/L
	Dibenz (ah) anthracene	0.001	mg/L
	Fluoranthene	0.001	mg/L
	Fluorene	0.001	mg/L
	Indeno (1,2,3-cd) pyrene	0.001	mg/L
	Naphthalene	0.001	mg/L
	Phenanthrene	0.001	mg/L
	Pyrene	0.001	mg/L
	Carcinogenic PAHs (benzo[a}pyrene equivalents		

Group	Analyte	Limit of reporting	Units
	Total PAH	0.001	mg/L
Phenols	2,3,4,6-Tetrachlorophenol	0.005	mg/L
	2,4,5-Trichlorophenol	0.005	mg/L
	2,4,6-Trichlorophenol	0.005	mg/L
	2,4-Dichlorophenol	0.005	mg/L
	2,4-Dimethylphenol	0.005	mg/L
	2,4-Dinitrophenol	0.005	mg/L
	2,6-Dichlorophenol	0.005	mg/L
	2-Chlorophenol	0.005	mg/L
	2-Methyl-4,6-dinitrophenol	0.005	mg/L
	2-Nitrophenol	0.005	mg/L
	4-Chloro-3-methylphenol	0.005	mg/L
	4-Nitrophenol	0.005	mg/L
	Dinoseb	0.005	mg/L
	Hexachlorophene	0.005	mg/L
	m- and p-Cresol	0.005	mg/L
	Pentachlorophenol	0.005	mg/L
	Phenol	0.005	mg/L
Organic carbon	Dissolved Organic Carbon (DOC)	1	mg/L
	Total Organic Carbon (TOC)	1	mg/L
Other analytes	Bromide	0.01	mg/L
	Chlorine/Chloride	1	mg/L
	Formaldehyde		mg/L

Source- table C.8 Code of Practice

Appendices

Appendix A: Storage tank water balance investigation Northern Territory climate analysis

wrm water + environment

Memorandum

Date	8 July 2019	Pages	16
Company	Santos Ltd		
Job No.	1413-17-B1		
Subject	Climate analysis for Beetaloo location (Northern Territory)		

This memorandum documents an analysis of climatic data for one of Santos Ltd's (Santos') operational areas in the Northern Territory (NT). The intent of the analysis is to provide information that can be used by Santos to set maximum operating levels in open water storage tanks used to store produced water or flowback fluid generated as part of petroleum extractive activities within the area.

Subject site

Details of the subject site are outlined below:

- Name: Santos McArthur Basin 2019 Hydraulic Fracture Program
- Latitude: -16.5
- Longitude: 134.85

Figure 1 is a locality plan showing the site and other points of interest within the NT. The site is located approximately 630 km south-east of Darwin, and approximately 180 km south-west of the nearest coastline (Gulf of Carpentaria).

Context

The *Code of Practice: Onshore Petroleum Activities in the Northern Territory* (NT Government, 2019) (version 2 dated 31/5/19) (the code) outlines requirements for the management of produced water or flowback fluid, including development of a waste water management plan (WWMP). This memorandum has been prepared to support Santos in meeting the requirements of the code. In particular, this memo provides the following information:

- 0.1% (1 in 1,000) annual exceedance probability (AEP) freeboard provisions and the associated basis of their estimation; and
- consideration of procedures and trigger criteria governing the transfer of water from open tanks into enclosed tanks during the wet-season, in response to significant forecast rainfall.

Parts of the code relating to these items are reproduced in the following section.

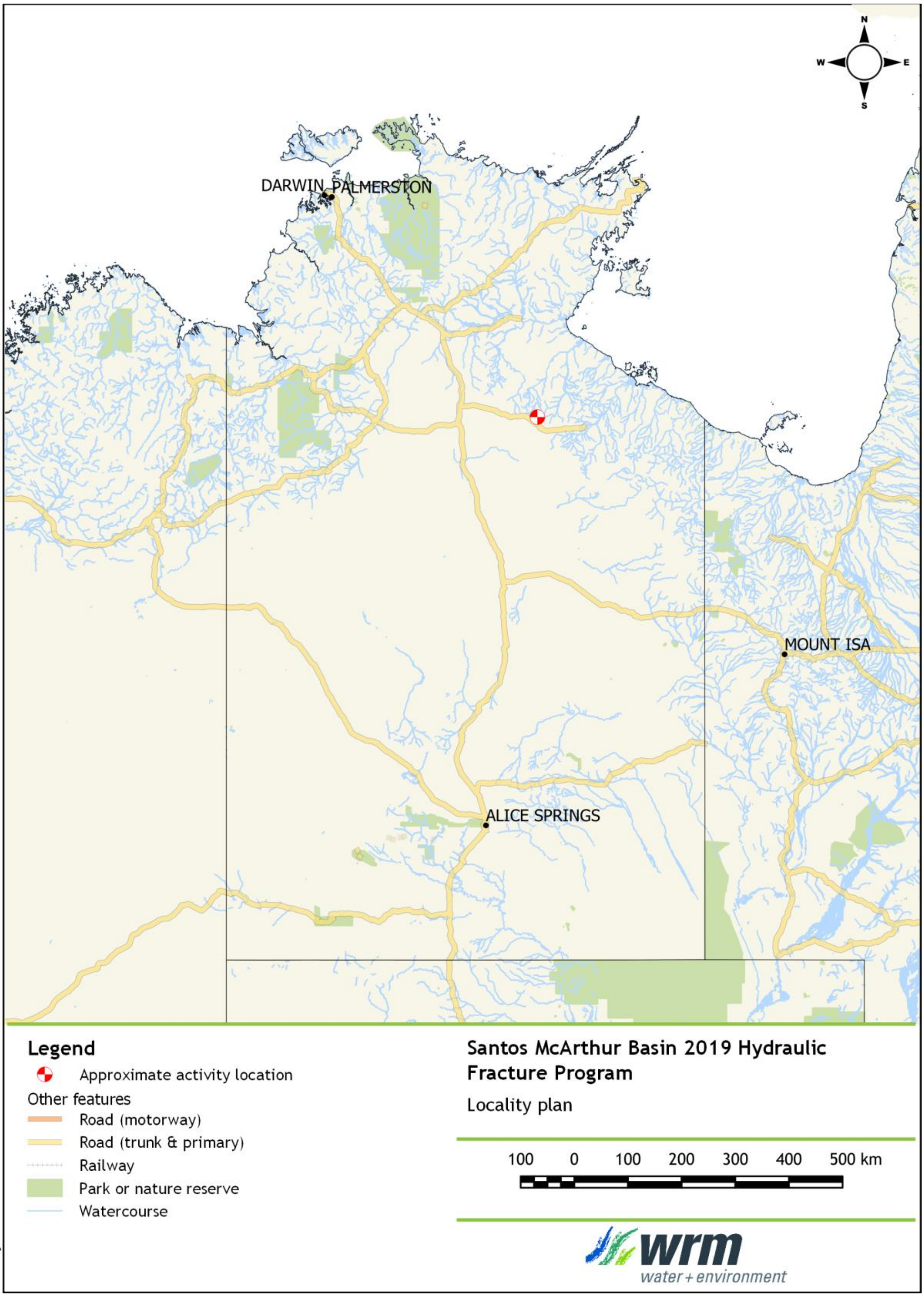


Figure 1 – Locality plan

Relevant sections of the code

Relevant sections/conditions of the code have been reproduced below, for context:

C.7.1 – Wastewater management plan

> *a) an environmental management plan (EMP) for a petroleum activity must include a WWMP.*
>
> *c) the WWMP must include…:*
>
> > *v. Estimates for the 1 in 1000 average recurrence interval (ARI)*[1] *rainfall rate using Australian Rainfall & Runoff (AR&R) methodologies for the critical period during which there would be greatest risk of overtopping of any structures holding wastewater which are not enclosed.*

C.7.1.1 – Wastewater treatment, reuse and disposal

> *a) For any proposed produced water and flowback fluid treatment processes occurring outside of enclosed tanks (including volume reduction via evaporation) the WWMP must demonstrate that all associated environmental risks and environmental impacts have been reduced to a level that is as low as reasonably possible (ALARP) and acceptable and must:*
>
> > *ii. Include a plan to transfer produced water and flowback fluid into above-ground enclosed tanks at least 8 hours in advance of any predicted significant rainfall event as specifically defined based on local weather conditions and other site-specific risks;*
> >
> > *iv. Specify minimum freeboard for treatment infrastructure to accommodate total rainfall anticipated (based on 1:1000-year ARI rainfall estimates, as determined in C.7.1 (c) v.) for the period that treatment infrastructure contains wastewater;*

[1] This memorandum uses annual exceedance probability (AEP) terminology instead of the average recurrence interval (ARI) terminology used in the code. This is consistent with standard notation used by the Bureau of Meteorology (BoM).

Memorandum

Freeboard requirements

This section outlines 0.1% AEP freeboard provisions for the subject site and the associated basis of their estimation.

Adopted freeboard requirements (wet-season containment)

Freeboard requirements have been assessed for a scenario in which produced water and/or flow back water remains in an open tank for the duration of the wet-season. In order to contain seasonal 0.1% AEP rainfall inputs, there must be 1,168 mm of freeboard available between the standing water level and the overflow level of any open tank at the start of the wet-season (nominally Nov 1st).

The following points outline the methodology used to calculate the above. Note that additional supporting information (analysis/figures etc) is provided in Attachment A.

- A 130-year climate time-series was sourced for the site location from the Queensland Government SILO Data Drill service. The time-series includes interpolated rainfall data and estimates of evaporation based on interpolated meteorological parameters;
- Wet-season rainfall totals were extracted from the SILO Data Drill time-series, and were then ranked and fitted with a Log Pearson Type III (LPIII) distribution. The 0.1% AEP rainfall depth was extrapolated using the LPIII distribution;
- Evaporation depths for the 0.1% AEP wet-season were estimated based on a linear regression line fitted to a plot of historical evaporation versus rainfall. Note that the trends exhibited in the historical data show that evaporation depths are typically lower in years with high rainfall;
- The 20 highest rainfall years within the 130-year SILO time-series were identified. The temporal distribution of rainfall within each of these years was analysed and used to define a proportional temporal pattern (i.e. x% of wet-season rainfall falls on day 1, y% on day 2 etc). A set of 0.1% AEP wet-season rainfall sequences was defined by scaling each of these 20 proportional temporal patterns by the 0.1% AEP total rainfall depth sampled from the LPIII distribution. The same process was repeated to generate 20 corresponding evaporation sequences;
- A simplified water balance model was constructed, with rainfall and evaporation being the only inputs and outputs. The model assumed storage in a vertical-walled open tank, and all calculations and results were expressed in terms of mm depth. The model was used to simulate twenty different 0.1% AEP wet-season climate sequences. The maximum change in inventory (depth) out of all twenty climate sequences was adopted as the 0.1% AEP freeboard. Note this was taken to be the difference between the minimum and maximum inventory, not the difference between the starting inventory and maximum.

Conservative assumptions employed in the above methodology include:

- Use of lake evaporation loss rates instead of pan evaporation loss rates (the former being lower, and generally more appropriate for estimating losses from large open bodies of water that influence their overlying climate as opposed to a tank which is more akin to a point source of water);
- Selecting freeboard depths based on the difference between the minimum and maximum simulated inventories that occurred throughout the simulation, rather than based on the difference between the starting depth

and maximum depth. This assumption effectively ignores any evaporation that occurred prior to reaching the minimum inventory;

- Further to the above, selecting freeboard requirements based on the worst-case result out of the twenty simulated temporal patterns, rather than based on a central estimate (e.g. median, or average).

Other considerations

Note that climate change effects have not been taken into consideration as part of the methodology used to estimated 0.1% AEP freeboard requirements.

Wave action has not been considered as part of this analysis. Freeboard provisions designed to accommodate 0.1% AEP rainfall inputs should be adequate to also manage wave heights that may occur within the tank under high wind conditions. Secondary spill prevention systems (i.e. bunding around tanks) should also be an effective control to manage risk associated with wave induced overtopping.

Other design rainfall data (for reference)

Design 1,000-year ARI rainfall depths for durations between 1 day and 7 days have been sourced from the Bureau of Meteorology (BoM). These depths have been summarised in Table 1. The intent of this information is to provide context to the adopted seasonal freeboard (1,168 mm). Rainfall data for other durations and other ARI have been included in Appendix B for reference.

Table 1 - BOM IFD rainfall data - 1000 yr ARI

Duration (h)	Duration (days)	Rainfall (mm)
24	1	405
48	2	518
72	3	575
96	4	609
120	5	631
144	6	645
168	7	654

Evaporation

Monthly evaporation depth totals have been listed in Table 2 for the 10th, 50th and 90th percentiles respectively (labelled as P10, P50 and P90) for Santos reference. Percentiles are based on 130 years of SILO Data Drill lake evaporation data.

Table 2 - Monthly evaporation depths (mm) - SILO lake evaporation

P%	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
P10	172	139	150	145	127	106	116	146	171	199	200	184	1,945
P50	195	167	179	160	135	114	124	152	180	213	213	210	2,043
P90	218	193	202	171	143	122	130	157	187	222	225	230	2,119

It is understood that Santos may wish to use historical evaporation rates to estimate how long it may take to draw down the inventory in an open tank to a target level. Net evaporation depths (i.e. evaporation offset by rainfall) are more appropriate for this purpose. Net evaporation depths are listed in Table 3 (based on lake evaporation minus rainfall).

Table 3 - Monthly net evaporation depths (mm) (evaporation minus rainfall)

P%	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
P10	-127	-215	-105	86	116	96	112	145	165	172	107	-57	980
P50	43	11	88	153	133	114	123	152	179	206	183	117	1,399
P90	163	158	177	169	143	122	130	157	187	220	211	199	1,690

Net evaporation depths have been presented in cumulative terms in Figure 2 from a 1 April starting point (notionally the end of the wet-season, as defined in the code). Note the vertical axis of Figure 2 has been inverted.

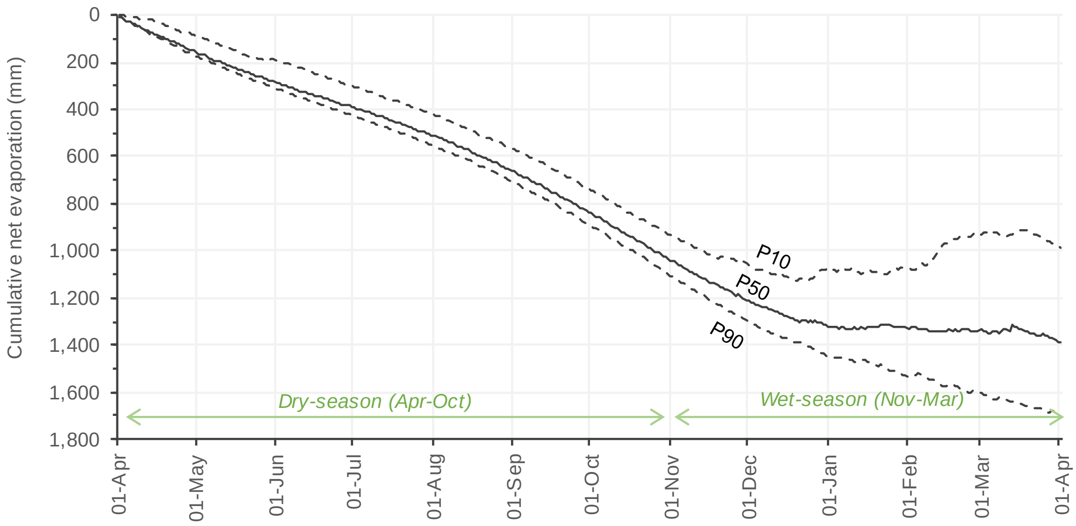


Figure 2 - Cumulative net evaporation (including rainfall) starting 1 April

Transfer protocols

The code requires that Santos include in their WWMP, procedures and trigger criteria to commence the transfer of produced water and flowback fluid from open to enclosed tanks in response to a significant rainfall event. WRM recommend that Santos consider the following when designing these procedures/triggers:

- Prior to the start of the wet-season (Nov 1st):
  - Pumped transfers to the closed tank(s) should occur to ensure there is at least 1,168 mm freeboard available in all open tanks on Nov 1st (this will ensure that the tank will not overflow in a 0.1% AEP wet-season if for some reason it can't be pumped into or out of);
  - Ensure there is adequate storage capacity in the closed tank(s) to accommodate expected inflows over the November to March period (inclusive) based on:
    - The freeboard depth of 1,168 mm multiplied by the surface area of any connected open tanks; and
    - The estimated volume of produced water or flowback fluid reporting to any connected open tanks;
- At any point throughout the year:
  - Pumped transfers to the closed tank(s) should occur to ensure there is always enough freeboard in any open tank to contain a short duration 1,000-year ARI rainfall event (i.e. 654 mm which corresponds to a 0.1% AEP 7-day design rainfall). This would leave a 514 mm margin between the 1st Nov level and the pump trigger level that will act as a climate buffer; and
  - Santos should monitor rainfall forecasts published by the BOM and initiate pumping (within 72 hours) of all water into the closed tank(s) if the forecast rainfall is greater than 654 mm (0.1% AEP 7-day design rainfall).

Risk to persons and environment

The intent of the code is to establish design/management requirements that will reduce risk to the environment and/or persons associated with a potential failure to contain produced water or flow back fluid. Risk is a product of likelihood and consequence.

Likelihood:

- The potential likelihood of failure of containment due to rainfall is reduced by the implementation of the following management controls:
  - Maintenance of 0.1% AEP freeboard during operation;
  - Availability of 100% contingency storage with the ability to transfer the full storage capacity;

Consequence:

- In the event of a rainfall event that is significant enough to overcome these controls, the potential impact on the receiving environment (i.e. the consequence) would be reduced by the following mechanisms:
  - Dilution of stored produced water and flowback water with significant quantities of rainfall prior to overflow;

- Poor mixing of rainwater and underlying produced water or flowback fluid due to density differences, resulting in overflows being comprised mostly of rainwater;
- Containment of overflow water within perimeter bunding, and further dilution with rainfall that had accumulated within the bunded area;
- Dilution of overflow water with background environmental flow; and
- Short-term nature of the event (overflow can only occur when it is raining).

The design and management practices for the storage of flowback fluid and produced water (as proposed above) adequately manage the overall risk to persons and the environment to ALARP (as low as reasonably possible).

For and on behalf of

WRM Water & Environment Pty Ltd

Gavin Rootsey

Principal Engineer

References:

NT Gov, 2019 — *'Code of Practice: Onshore Petroleum Activities in the Northern Territory'* Northern Territory Government, Department of Primary Industry and Resources & Department of Environment and Natural Resources, May 2019.

Qld Gov, 2019 — *'SILO Data Drill'* https://silo.longpaddock.qld.gov.au/

ATTACHMENT A – FREEBOARD CALCULATIONS – SUPPORTING INFORMATION

Climate characteristics

Rainfall and evaporation data for the Beetaloo Basin site was obtained from the Queensland Climate Change Centre of Excellence (QCCCE) SILO Data Drill Service. The rainfall and evaporation datasets span from January 1889 to January 2019. Average monthly rainfall and evaporation depths are presented in Figure A1. Historical annual rainfall totals are presented in Figure A2.

Figure A1 shows that rainfall in the Beetaloo Basin is strongly seasonal, with most rain falling between November and April. The average annual rainfall at the site is 684 mm, and the average annual (pan) evaporation is 2,671 mm.

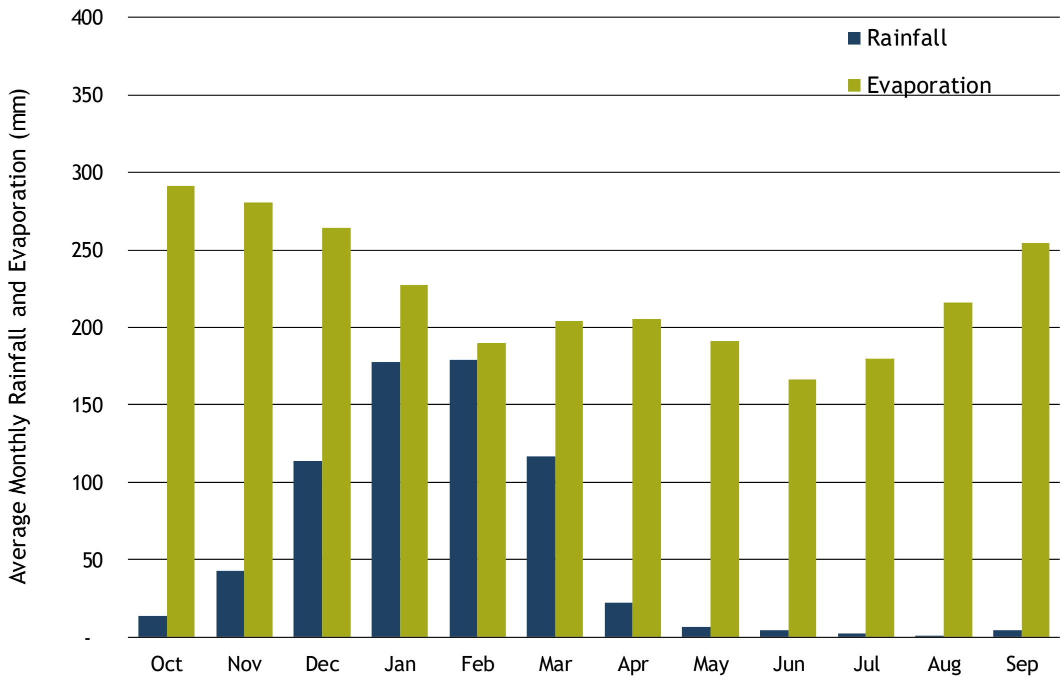


Figure A1 - Average monthly rainfall and pan evaporation

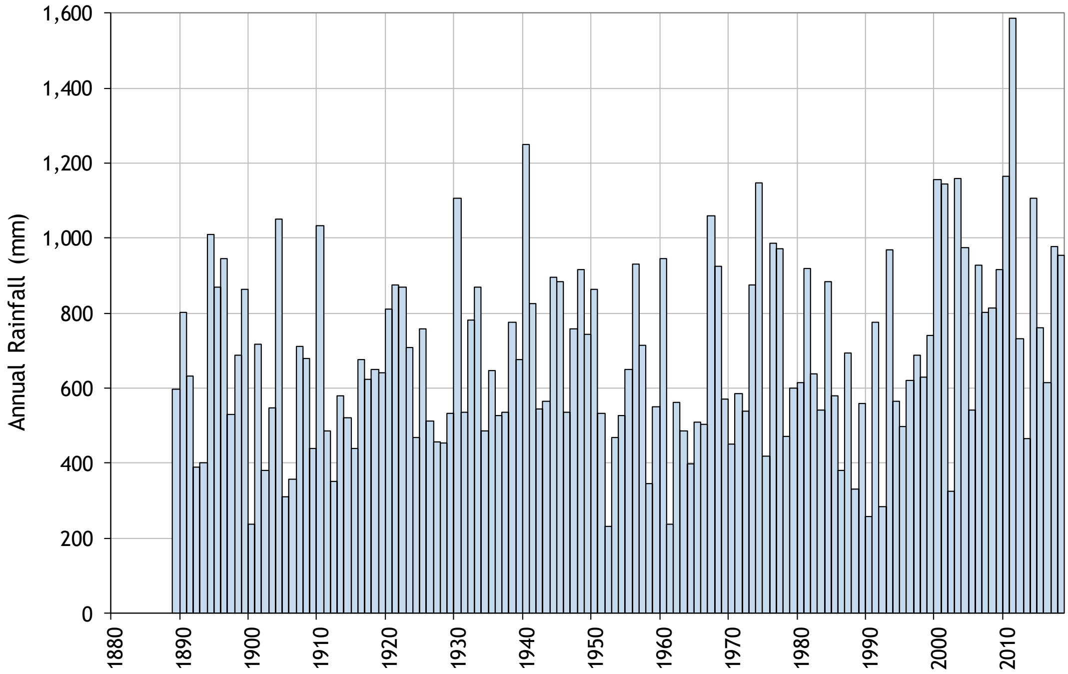


Figure A2 - Annual rainfall

Methodology and Results

Estimation of 0.1% AEP rainfall depth

For the purposes of this analysis, the 0.1% AEP rainfall depth has been assessed for a continuous 90-day period, that occurs at some point throughout the year (nominally within the wet-season).

The following methodology was used to estimate the 0.1% AEP rainfall depth.

1. For each day in the climate dataset, sum the rainfall and evaporation over the preceding 90 day period;
2. Identify the highest 90 day rainfall total in each calendar year to create an annual time series of 90 day maxima (130 annual maxima);
3. Rank the 90 day maxima and fit a Log Pearson Type III (LPIII) distribution;
4. Extrapolate the LPIII distribution to estimate the 0.1% AEP rainfall depth.

Note that the potential effects of climate change have not been incorporated into this analysis.

The LPIII distributions to the annual series of 90-day rainfall maxima are shown in Figure A3[2]. The 3-month, 0.1% AEP rainfall total is estimated to be 1,448 mm. Note this is almost equal to the highest 12-month rainfall total reported in the 130-year SILO Data Drill time-series (see Figure A2).

[2] Note the horizontal scale in the LPIII figures follows the terminology specified in the 2016 version of Australian Rainfall and Runoff (Book 1, Chapter 2.2.5). EY denotes events per year, and is the inverse of 'average recurrence interval' (ARI).

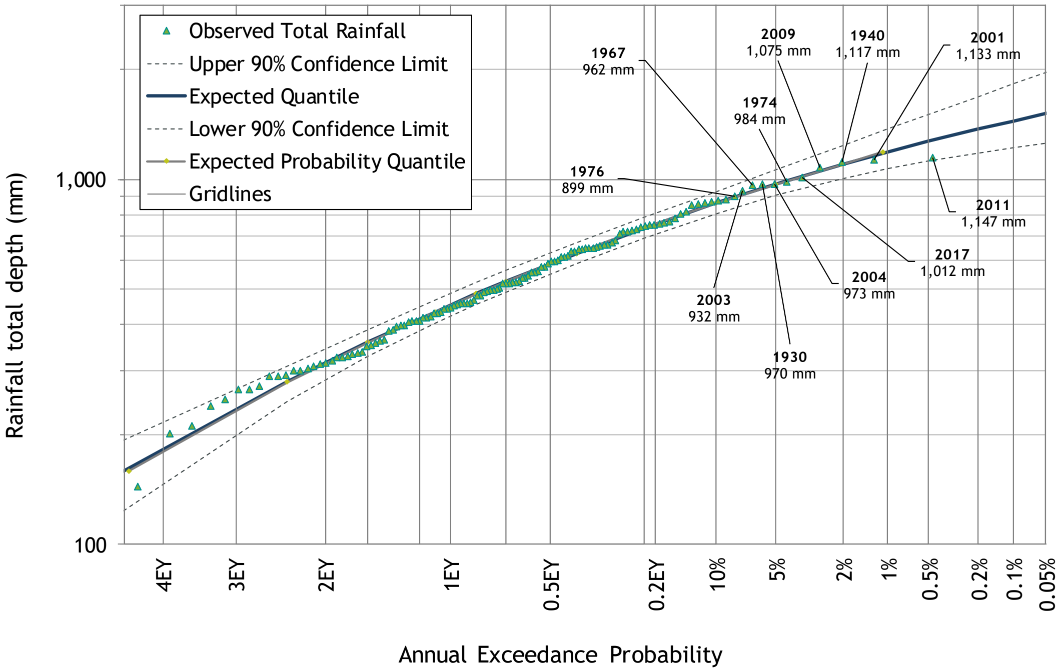


Figure A3 - Fit of LPIII Distribution to annual series of 90 day rainfall depths

Estimation of total evaporation coinciding with 0.1% AEP rainfall

The Data Drill estimates of Morton's lake evaporation were adopted for estimating evaporative losses from the tank water surface.

As shown in Figure A4, in the Beetaloo basin, elevated 90 day rainfall totals are associated with reduced evaporation. For the purpose of this investigation, a linear regression line was applied to this relationship, and extrapolated to estimate the evaporation associated with the 0.1% AEP.

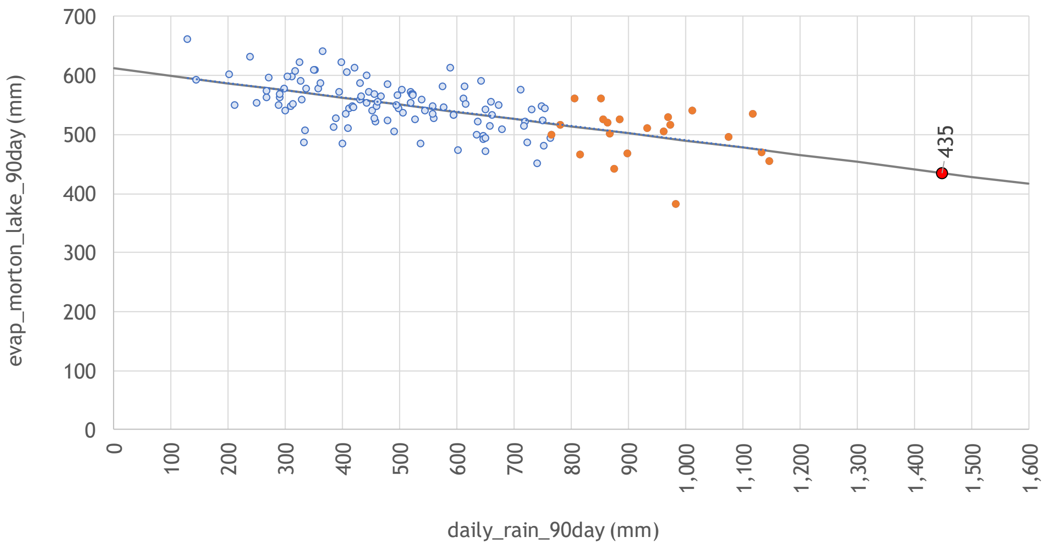


Figure A4 - Relationship between 90 day rainfall depth and evaporation

Derivation of 0.1% AEP daily timestep climate datasets for water balance model

The climate dataset was sampled 20 times – each sample commencing at the start of one of the 20 largest 90 day rainfall events.

The resultant ensemble of 20 – 366-day long rainfall and evaporation temporal patterns was used for the analysis. The first 90 days of each cumulative rainfall temporal pattern are shown in Figure A5.

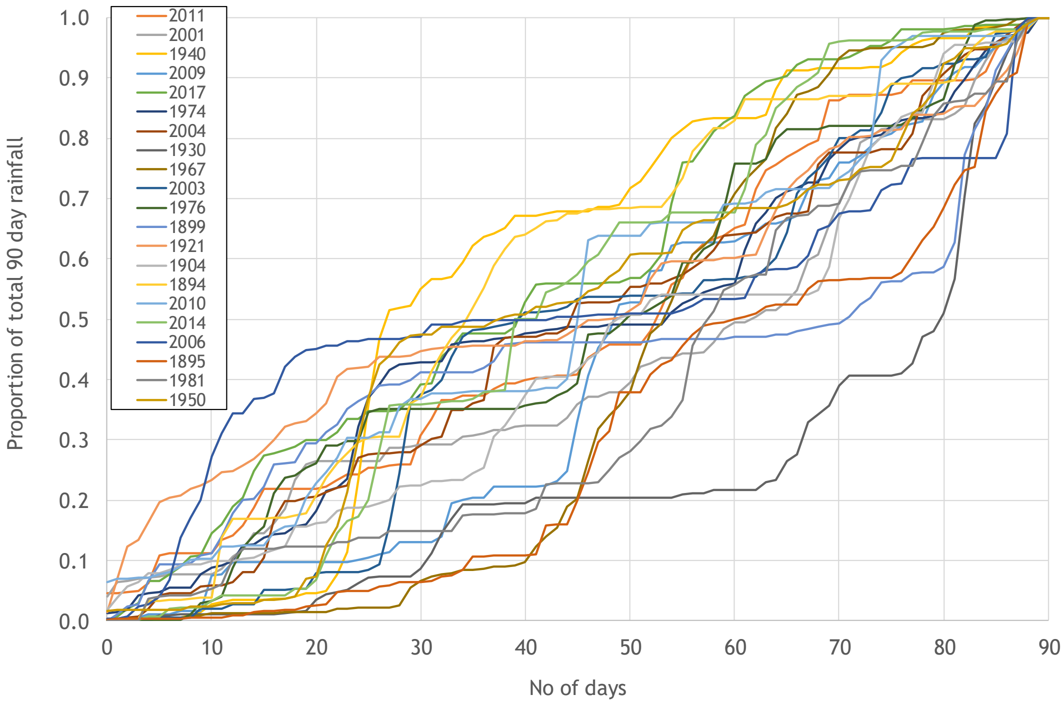


Figure A5 – Ensemble of 20 rainfall temporal patterns (first 90 days)

The first 90 days of each rainfall temporal pattern was scaled up by the ratio of the 0.1% AEP 90 day rainfall (i.e. 1,448 mm) to the 90 day total for that event.

The first 90 days of each evaporation temporal pattern were also factored by the ratio of the 90 day evaporation estimate from the previous step to the 90 day total for that event.

Model Results

The adopted climate data was input to a very simple water balance model in which daily tank water level on each day is estimated as:

Tank WL_n = Tank W_{n-1} + Rainfall – (M_{lake} to Tank Evap Factor) *(M_{lake} Evap)

Where (M_{lake} to Tank Evap Factor) = 1.0

The results of the model are summarised in the table below and in the following figures. When reviewing the figures, please note the following:

- The starting condition has been adjusted to ensure that no temporal patterns result in negative water levels;
- Extended outlook figures show 0.1% AEP rainfall conditions for the first 90 days of the simulation, and historical climate for the remainder of the simulation period (i.e. total rainfall modelled over the 366 day sequence was higher than the 0.1% AEP rainfall modelled in the initial 90 day period).

The intent of these figures is to give an indication as to how the water levels in the tank may recover (or otherwise) after a 0.1% AEP rainfall sequence, if the tank were left in place for longer than three months.

Table 1 - Summary of tank water balance model results (all units: mm)

Item	Value (mm)
0.1% 90-day AEP rainfall [A]	1,448[C]
Co-incident evaporation	-435
Net 90-day water level increase	1,013
Max water level increase during the 90-day period[B]	1,168

[A] Based on all months (not wet season only)

[B] The largest difference between minimum and maximum water level occurring during the 90d simulation period, out of the 20 temporal patterns.

[C] Note that BOM IFD 0.1% AEP 7d design rainfall is 682 mm for Beetaloo Basin location. This rainfall can notionally occur at any time throughout the year.

[D] Note that BOM IFD 0.1% AEP 7d design rainfall is 492 mm for Amadeus Basin location. This rainfall can notionally occur at any time throughout the year.

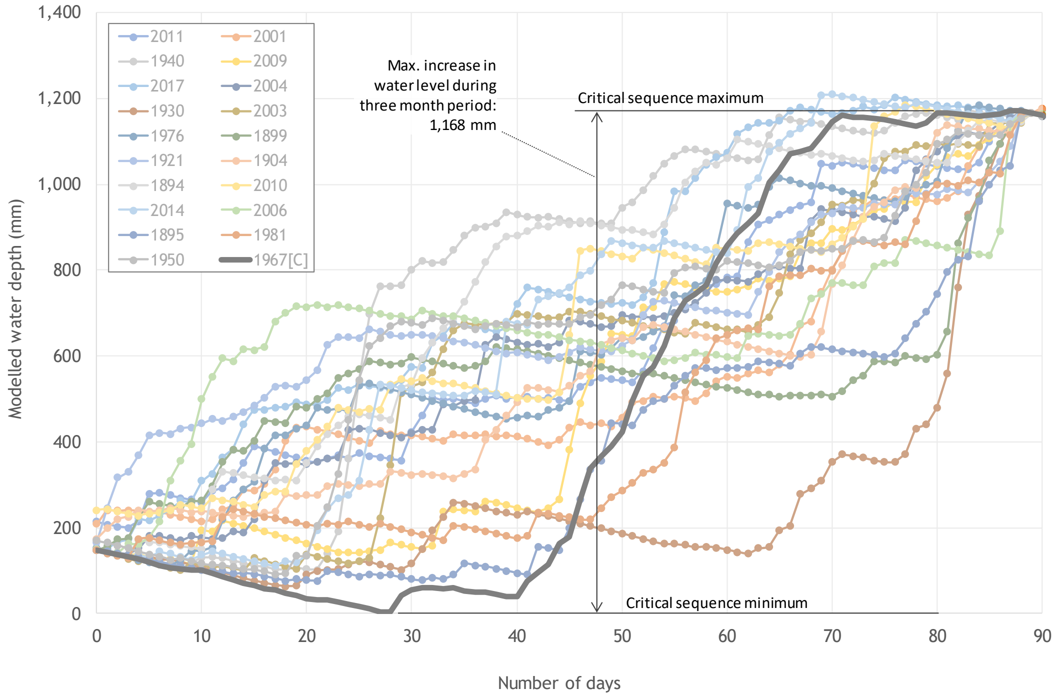


Figure A6 - Water balance model results - all months - 90 days

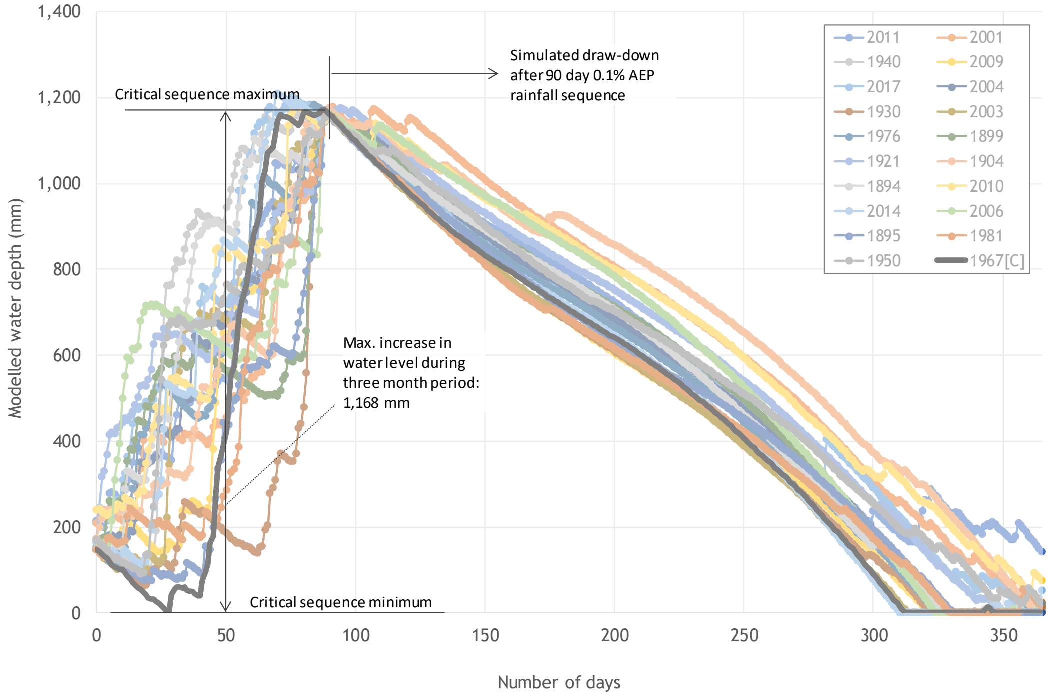


Figure A7 - Water balance model results - all months - 366 days

ATTACHMENT B – IFD INFORMATION

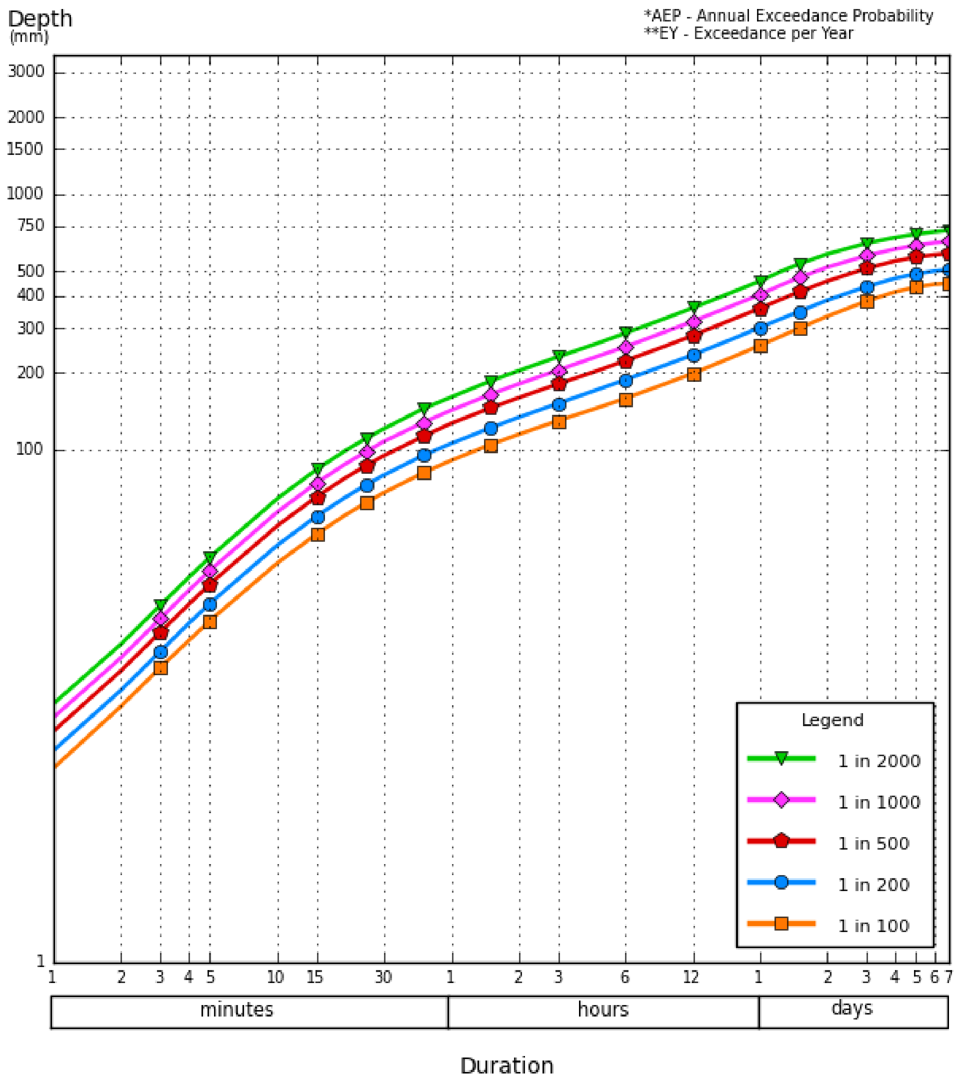
Label:Beetaloo

Requested coordinate	Latitude: -16.5000	Longitude: 134.8500
Nearest grid cell	Latitude: 16.4875 (S)	Longitude: 134.8625 (E)

Rare Design Rainfall Depth (mm)

Issued: 21 May 2019

Rainfall depth in millimetres for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP).

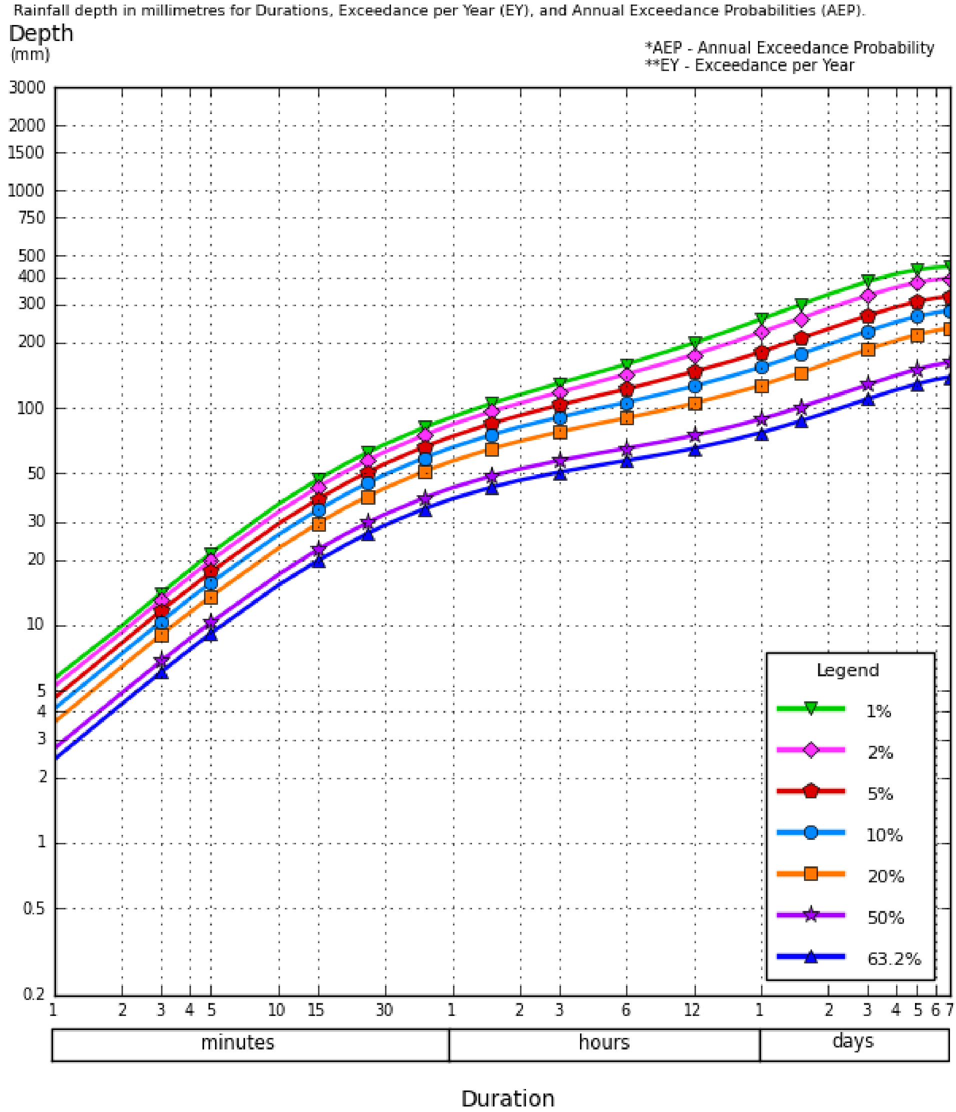


Label:Beetaloo
Requested coordinate Latitude: -16.5000 Longitude: 134.8500
Nearest grid cell Latitude: 16.4875 (S) Longitude: 134.8625 (E)

IFD Design Rainfall Depth (mm)

Issued: 21 May 2019

Rainfall depth in millimetres for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP).



Santos

Appendix H: Spill Management Plan

Santos

Spill Management Plan: McArthur Basin Hydraulic Fracture Program

NT Exploration Permit (EP) 161

Date	Rev	Reason for Issue	Author	Checked	Approved
30/05/2019	0	For Submission	MB	PW	DC
2/10/2019	1	For Submission	MB	PW	DC
14/10/2019	2	For Submission	MB	PW	DC

Santos

Table of Contents

Tables

Figures

Abbreviations and Units

Acronym / Abbreviation	Description
ALARP	As low as reasonably practicable
ALRA	Aboriginal Land Rights Act
AAPA	Aboriginal Areas Protection Authority
APPEA	Australian Petroleum Production and Exploration Association
CLA	Cambrian Limestone Aquifer
Code	Code of Practice
CPESC	Certified Professional in Erosion and Sediment Control
DENR	Department of Environment and Natural Resources
DoEE	Department of Environment and Energy
DFIT	Diagnostic Fracture Injection Test
DPIR	Department of Primary Industry and Resources
D&C	Drilling and Completions
EC	Electrical Conductivity
EMP	Environmental Management Plan
EP	Exploration Permit
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
EPS	Environmental Performance Standards
ERA	Environmental Risk Assessment
EWCRP	Emergency Well Control Response Plan
ESD	Ecologically Sustainable Development
ha	Hectares
HFS	Hydraulic Fracture Stimulation
GISERA	Gas Industry Social and Environmental Research Alliance
km	Kilometre
LACA	Land Access Compensation Agreement
LWD	Logging While Hydraulic fracture program
NLC	Northern Land Council
m	Metres
MD	Measured Depth
MoC	Management of Change
ML	Megalitres
NRM	Natural Resource Management
NT	Northern Territory
NT EPA	Northern Territory Environmental Protection Authority
NVIS	National Vegetation Information System
Panel	Independent Scientific Panel

Acronym / Abbreviation	Description
PL	Petroleum Lease
PMST	Commonwealth Protected Matters Search Tool
PPL	Petroleum Pipeline Licence
SEAAOC	South East Asia Australia Onshore Conference
SMS	Santos Management System
SSCC	Sacred Site Clearance Certificate
TOC	Total Organic Content
TPWC Act	Territory Parks and Wildlife Conservation Act 2014
TVD	True Vertical Depth
TVDSS	True Vertical Depth referenced to sea-level (Australian Height Datum)
WOMP	Well Operations Management Plan
WoNS	Weed of National Significance

1.0 Introduction

1.1 Background

Santos proposes to undertake exploration activities in the McArthur Basin in 2019 through to 2020, this Spill Management Plan (SMP) is in support of the Hydraulic Fracture Program Environmental Management Plan.

Under the Petroleum (Environment) Regulations (the Regulations), interest holders in petroleum titles must prepare and submit an Environment Management Plan (EMP). Approval of an EMP is necessary for all activities that have an environmental impact or risk and is only one of several approvals required for the activity to proceed. An approved EMP is a statutory document that is enforceable.

The Code of Practice for Petroleum Activities in the Northern Territory sets out the mandatory requirements for management plans for wastewater and spills. The Code states that an EMP for a petroleum activity must include a Spill Management Plan.

1.2 Scope

This spill management plan assesses and manages the risks posed by potential spills of waste, wastewater, fluids and any chemical additives used or stored as part of the Hydraulic Fracturing Program at the Tanumbirini 1/2H and Inacumba 1/1H locations. The Hydraulic Fracturing Program EMP does not cover the Drilling program scope of work, a separate SMP has been developed to support the 2019 drilling program EMP.

2.0 Potential Spill Materials

A list of chemical additives, fluids, fuels and wastewater and the way that they will be stored, transported and transferred as part of activity is provided below.

2.1 Chemicals and Wastewater associated with the Activity

Table 2-1 Estimated Volumes and Storage of chemicals and fuels

Description	Volume stored onsite	Storage Location	Containment
Liquid Stimulation Chemicals	0.5 ML	Storage tanks & drums	Secondary containment (double skinned tank or bunded containment area or bunded pallet storage)
Stimulation Fluid **(Blended on the fly)**	32.5 ML	Engineered tank pad	Secondary containment (engineered tank in bunded containment)
Flowback Fluid	25 ML	Engineered tank pad	Secondary containment (engineered tank in bunded containment)
Chemical Tracers	<25kg	Storage tanks & drums	Secondary containment (double skinned tank or bunded containment area or bunded pallet storage
Diesel Fuel	100 m^3	Rig Fuel storage Tanks (Double Skinned)	Secondary containment
Hydraulic Oil	3.8 m^3	Storage tanks & drums	Secondary containment (double skinned tank or bunded containment area or bunded pallet storage)
Other Chemicals **(excluding hydraulic fracture program additives)**	10 m^3	Oil storage skid or mechanics shack	Secondary containment (double skinned tank or bunded containment area or bunded pallet storage)

2.1.1 Grey water and Sewage

Camp wastewater from laundry, showers and kitchen is proposed to be piped to an irrigation area. For treated sewage is sewage that has passed through a sewage treatment system, the liquid component of the sewage treatment is either disposed of using an irrigation system or transported with the solid waste to an approved disposal facility. Macerated sewage is not treated sewage.

2.1.2 Diesel and Fuels

Hydraulic fluid and fuel drums are stored within portable bunding and bulk fuel is stored within tankers equipped with safety features such as double-skins (or temporary bunding), safety cut-off valves, top accessing etc. Spill leak and drip trays will be used to address the risk of minor drips and spills associated with re-fuelling operations.

2.1.3 Hydraulic Fracture Stimulation Fluids

Stimulation fluids are water based and all chemical additives used in Australia must be approved for use by the Commonwealth Government, Department of Health and listed on the Australian Inventory of Chemical Substances which is maintained under the National Industrial Chemicals Notification and Assessment Scheme. No hydraulic fracture stimulation fluids that are used in the process contain benzene, toluene, ethylbenzene and xylene as additives.

Hydraulic fracture stimulation (HFS) involves the injection of hydraulic fracturing fluids at high pressure into a cased wellbore, it is usually conducted over a number of intervals or stages along the production zone of the well. In hydraulic stimulation treatments, water accounts for more than 90% of the mixture and sand or proppant accounts for about 5-9%. Chemical additives generally account for less than 1% of the mixture. A list of fluid additives potentially used in the activity are provided in Table 2-2.

It is anticipated that approximately 32.5 ML of stimulation fluid will be required per well, this will be stored in engineered tanks within a bunded tank pad. The tank pad has been designed to have sufficient freeboard to contain rainfall inflow to an annual exceedance probability (AEP) of 1 in 1,000 (0.1%) over the duration of the activity.[1] Figure 1 demonstrates freeboard allowances and figure 2 details the layout of the tank pad along with its design features.

2.1.4 Chemical Tracers

Chemical Tracer tests will be applied at each fracture stimulation stage to determine the effectiveness and contribution of each stage. The chemical tracers are 100 percent water soluble and are added to the stimulation fluid at the wellhead. Once the well has been cleaned out and commissioned, the concentration of chemical traces detected during flowback can be measured. The anticipated volumes of chemical tracers additives are provided in Table 2-1. Chemical tracers will be stored in Bunded chemical storage areas or bunded pallet storage, in accordance with the code.

[1] See Wastewater Management Plan

Table 2-2 Proposed Hydraulic Fracture Stimulation Chemicals

HALLIBURTON CONFIDENTIAL INFORMATION - ONLY TO BE USED FOR REGULATOR NOTIFICATION (QLD FORMAT)

Comments:
Santos Beetaloo Basin Fluid: Hybrid Treatment (per Stage) PreJob   Includes Slick, HVFR & Xlink

Total injected fluid volume (kiloliters):	1329.156

Comprising of: (Kilograms, liters or kiloliters)		
Base Fluid type (e.g. water)	**Liters**	**% of total volume**
Makeup Water	1250000	94.0%

Proppant type (e.g sand)	**Proppant Size**	**Kilograms**	**Liters**	**% of total volume**
Sand	100 Mesh	45359	17117	1.28779%
Ceramic	40/80	136078	50399	3.79182%

Any wet chemical constitutes:	**Liters**	**% of total volume**
Water in Products	4955	0.373%
Choline Chloride	1259	0.0947%
Guar gum	1033	0.0777%
Hydrotreated light petroleum distillate	600	0.0452%
Alcohols, C6-12, ethoxylated propoxylated	438	0.0329%
Hydrochloric acid	405	0.0305%
Acrylamide, sodium acrylate polymer	375	0.0282%
Ethanol	296	0.0223%
Sodium perborate tetrahydrate	244	0.0183%
Sodium Chloride	174	0.0131%
Ethylene glycol	165	0.0124%
Alcohols, C10-16, ethoxylated propoxylated	156	0.0118%
Ulexite	152	0.0114%
Fatty acids, tall-oil, ethoxylated	150	0.0113%
Amides, tall-oil fatty, N,N-bis(hydroxyethyl)	148	0.0111%
Butyl alcohol	144	0.0108%
Alcohols, C12-15, ethoxylated	135	0.0101%
Sodium hydroxide	134	0.0101%
Sodium polyacrylate	121	0.00908%
Acetic acid	88	0.00665%
Triethanol amine	72	0.00544%
Diethanolamine	43	0.00320%
Chlorous acid, sodium salt	40	0.00301%
Tributyl tetradecyl phosphonium chloride	38	0.00282%
Polyethylene glycol	27	0.00206%
Ethoxylated branched C13 alcohol	25	0.00188%
Sodium diacetate	25	0.00188%
Sobitan, mono-9-octadecenoate, (Z)	25	0.00188%
Sorbitan monooleate polyoxyethylene derivative	25	0.00188%
Sodium bisulfite	25	0.00185%
Methanol	22	0.00166%
Acrylamide acrylate copolymer	20	0.00153%
Cinnamaldehyde	20	0.00149%
Diethylene glycol	18	0.00136%
Citric acid	14	0.00102%
Crystalline silica, quartz	10	0.00077%
Amine oxides, cocoalkyldimethyl	6.1	0.00046%
Disodium octaborate tetrahydrate	5.9	0.00044%
Sodium persulfate	5.0	0.00038%
Benzaldehyde	2.8	0.00021%
Alcohols, C12-16, ethoxylated	1.2	0.000088%
Sodium iodide	0.31	0.000024%
Glutaraldehyde	0.11	0.000008%
Acrylonitrile	0.068	0.000005%
Sodium Sulfate	0.005	0.000000%

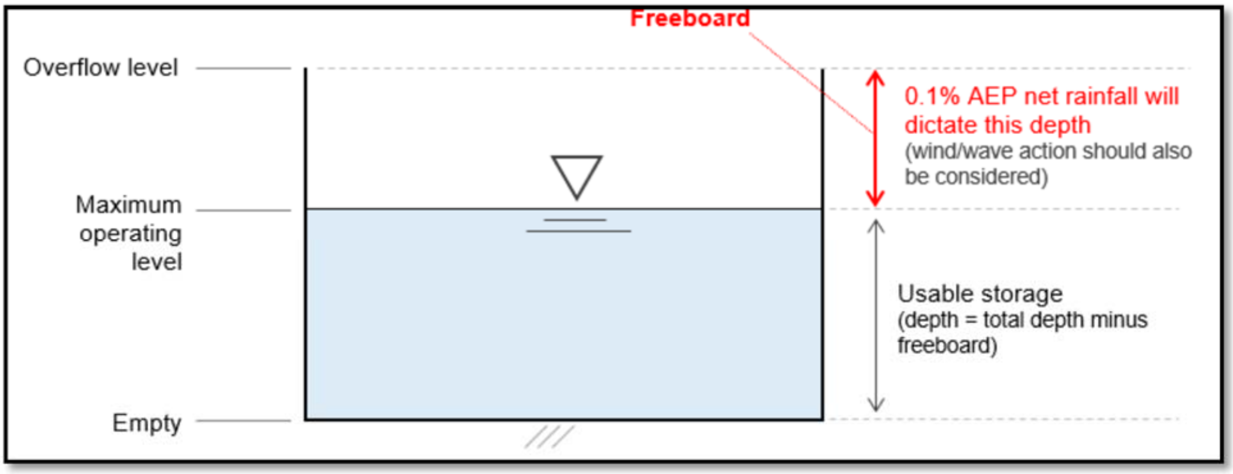
2.1.5 Flowback Fluids

Hydraulic fracture stimulation occurs in stages and is a completion technique conducted after a well integrity assessment has been completed. At the completion of each stage (it is anticipated that between 15-30 stages may be stimulated) the well is plugged while the next stage is perforated and fractured. This creates an increase in pressure, at completion of all stages the well is allowed to flowback to the surface, generating flowback fluid. The flowback of stimulation fluid, now mixed with products in the shale formation, is conducted through a separator which separates and captures liquids, and flares produced gas through a vertical 'flare stack'.

All flowback fluids will be stored in accordance with the NT code of Practice for Petroleum Activities. The flowback period of wastewater collection last typically 2 months after initial hydraulic stimulation, the anticipated flowback fluid volumes are provided in table 2-1.

Flowback fluids will be treated in engineered storage tanks held within a bunded tank pad that has been designed to hold sufficient freeboard to contain rainfall inflow to an annual exceedance probability (AEP) of 1 in 1,000 (0.1%) over the duration of the activity. Figure 2-1 demonstrates freeboard allowances and Figure 2-2 details the layout of the tank pad along with its design features.

Figure 2-1 Conceptual tank deign



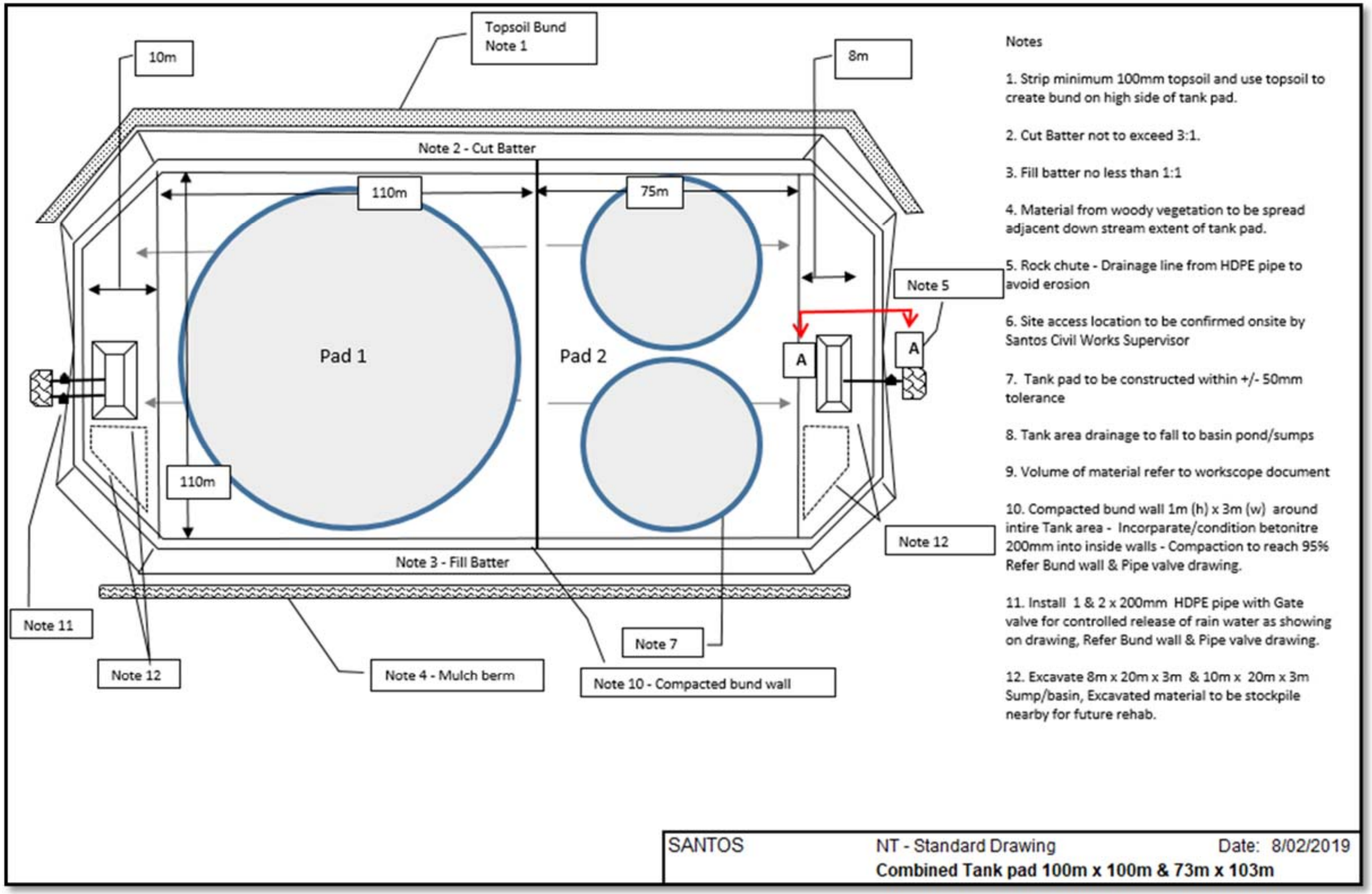


Figure 2-2 Indicative tank pad layout

3.0 Spill Risk Assessment

3.1 Potential Spill Scenarios

Spill scenarios have been assessed via a lifecycle assessment of chemical additives used during the hydraulic fracturing program, this includes the following general categories:

- Transportation of chemical additives – from the supplier warehouse to the well lease and between well leases.
- Hydraulic fracturing activities – storage, usage (e.g., blending, injecting) and subsequent recovery of fluids (including storage) at the well lease and associated vendor chemical additives.
- Disposal and Management – recovered vendor chemical additives in wastes and hydraulic fracturing flowback.

A lifecycle assessment has been conducted to evaluate the potential hazards associated with chemicals and the potential for exposures to human and environmental receptors from a number of pathways and spill scenarios, this is attached in Appendix A. Potential sources of spills during hydraulic fracture activities are shown in Table 3-1.

Table 3-1 Quality and quantity of spill scenarios

Potential spill scenario	Quantity of spill	Quality of spill	Design controls
Loss of containment of stimulation chemical additives and other substances from storage area	Less than 1m^3	Potentially hazardous	All chemicals will be stored in a bunded - Dangerous goods storage area All stimulation chemicals will be stored using secondary containment Spill kits available Routine inspection of chemical stores Sites are manned during operations
Loss of containment of stimulation chemical additives from blending unit	Less than 1m^3	Potentially hazardous	Other that the 2m^3 tank used to mix fluid and proppant all other mixing of fracturing fluids occur in enclosed systems, without risk of overspills. The downhole blender unit is computer automated and equipt with alarms Tanks levels are continuously monitored All mixing operations are directly supervised by a dedicated operator. Routine inspections of all hoses and treating lines to identify and isolate any potential leakage. All hoses and lines are flushed with freshwater prior to breaking lines at the completion of operations, with portable spill trays used when breaking connections. All bleed off lines are directed into flowback tanks.

Potential spill scenario	Quantity of spill	Quality of spill	Design controls
Loss of containment of flowback fluids from flowlines to storage tank	Less than 1m^3	Hazardous fluids	Flowline inspected prior to flowback and daily during operations installed lines leak tested with pressure test Tank storage volumes monitored for loss of containment
Loss of containment of flowback fluid from storage tank – storage tank failure	<12 ML	Hazardous fluids	Double lined tanks Leak detection system Tank pad will be bunded and capable of holding the carrying capacity of wastewater on the tank pad. Bunded tank pad will accommodate the volume of the largest tank Tank storage volumes monitored for loss of containment
Overflow due to rainfall event of flowback fluid from storage tank	Greater than 1m^3	Hazardous fluids	Tank pad bunded will be capable of holding the carrying capacity of wastewater on the tank pad. All produced water and flowback fluid must be held in above-ground enclosed tanks Any proposed produced water and flowback fluid treatment processes occurring outside of enclosed tanks will have minimum freeboard for treatment infrastructure to accommodate total rainfall anticipated (based on 1:1000 year ARI rainfall estimates.
Poor refuelling or fuel transfer practices	Less than 1m^3	Hazardous fluids	Secondary containment All chemicals will be stored in a bunded - Dangerous goods storage area Spill kits available Routine inspection of chemical stores

[1] *"Carrying capacity" of tank pad is equivalent to volume of all enclosed tanks including 50 cm freeboard. This is also equal to maximum carrying capacity of open tanks with mandatory minimum 1.5m operational freeboard for 0.1% 90-day AEP*

Release of a volume larger than the capacity of the bunded area is considered remote given that water is being transferred between tanks to support evaporation and as such the carrying capacity is less than the capacity of the bunded area at all times.

A Spill modelling and environmental fate analysis has been conducted and is attached as Attachment B of Appendix A of the EMP, a summary of these findings is presented in table 3-2. The modelling considers a worst case scenario where all management controls fail and the full extent of a spill event is realised. The demonstration of ALARP (As low as Reasonably Practicable) is achieved when the management controls are applied to the scenario and site monitoring and any remediation can be anticipated.

Table 3-2 Environmental fate analysis

Potential spill scenario	Volume of spill (m^3)	Extent of Spill Unmitigated area (m^2)	Fate of Spill Unmitigated	Extent of spill Mitigated
Loss of containment of flowback fluids storage tank – Scenario 1	1	121	Surface Soil <1m depth	Max extent of the spill would be contained within the bunded tank pad.
Loss of containment of flowback fluids from storage tank.- Scenario 2	100	47,954	Surface Soil <1m depth	Max extent of the spill would be contained within the bunded tank pad.
Loss of containment of flowback fluid from storage area - scenario 3	1,000	308,569	Surface Soil <1m depth	Max extent of the spill would be contained within the bunded tank pad.
Loss of containment of flowback fluid- from storage area – scenario 4	12,000	2,208,865	Soil to 1.5-2.5m depth If a continuous flow was available (which it's not) It would take 22 years to reach groundwater	Max extent of the spill would be contained within the bunded tank pad In the context of leakage from the largest tank a total of >15,300m^2 could be contained within the bunded area

3.2 Potential Impact to the Environment

Potential impacts to the environment as a result of a spill event include reduction in quality of groundwater, surface water or soils. These are discussed in more detail below.

Groundwater

Without adequate management controls in place, chemicals and fuels used during the hydraulic fracture program and flowback fluid stored in above ground engineered tanks may have the potential to overflow or leak to surface, infiltrate the ground and migrate to shallow groundwater. This may affect groundwater quality, however the potential risk to groundwater from hypothetical water tank releases were assessed in Attachment B of Appendix A of the EMP. This assessment demonstrates that impacts to groundwater are extremely unlikely.

The only mode of potential impact is infiltration to groundwater identified is in the context of containing releases to the bunded area. Infiltration modelling provided in the Appendix A of the EMP was conducted using highly conservative assumptions and determined that a single release was unlikely to infiltrate to groundwater.

Under the worst-case scenario where the sumps maintained a water level of 3m (the maximum depth of the sump), it would take 130 days to move through the first 1 metre of siltstone and approximately 22 years to reach the water table. This is considered highly unrealistic as this would assume a 3m head is maintained for 22 years. Considering a transition from saturated (with head) to unsaturated infiltration modelling, it is considered that the maximum vertical penetrate of fluids would be less than 2.5 metres and therefore readily addressed.

Surface Water

Without adequate management control in place, spills to surface have the potential to migrate to surface waters such as ephemeral watercourses. This has the potential to effect surface water quality and ecological values of that habitat.

In the context of leakage from the largest tank a total of 15,300m^2 could be contained within the bunded area. It should be noted that the potential release scenarios of 1 ML and 12 ML were considered assuming no the containment structures present (See Attachment B of Appendix A). This is solely conducted to demonstrate the effectiveness of the containment proposed.

Soil

For smaller hypothetical spills or releases (<1m^3), migration is likely to be contained within the surface soils and would be readily removed or remediated. If a larger hypothetical spill were to occur, such as that from a bulk tanker, or flowback fluid storage pond rupture there is the potential that product could infiltrate further.

Shallow lithology obtained from exploration well Tanumbirini-1 (See Appendix A) reveals two main hydrogeological units; a relatively impermeable siltstone/claystone followed by limestone which has highly variable hydrogeological properties, but the potential for high permeability.

The modelling provided in Attachment B of Appendix A indicates that a worst case spill scenario Based on the area of the bunded area (20,000 m^2) and a porosity of 0.4, a total of 8 ML of water will be contained within each 1 m of the soil column. In this context a release of 12 ML would only be sufficient to fully saturate to a depth of 1.5 m.

3.3 Risk Assessment Process

An assessment of potential environmental impacts and potential environmental risks posed by a spill event has been carried out. For completeness and consistency with the environmental risk assessment of all activities, this is presented in Section 6 of the EMP.

4.0 Procedures and Process

4.1 Minimising the Risk of a Spill

4.1.1 Santos SMS

Santos manages the environmental impacts and risks of its activities through the implementation of the Santos Management System (SMS). The SMS provides a formal and consistent framework for all activities of Santos employees and contractors. This SMP and the Project EWCRP have been developed in consideration of the Santos SMS, including:

- EWCRP – Emergency Well Control Response Plan for the Amadeus Basin and Beetaloo Basin
- SMS-MS1 Risk – ST13 Environmental Hazard Controls Procedure
- SMS-MS11 Incident and Crisis Management Standard
- SMS-MS1 Incident and Crisis – ST1 – Emergency and Crisis Management Procedure.

In addition to this the Santos Emergency Response Plan (ERP) and the Contractors ERP provide additional processes and procedures to minimise the risks of a spill.

4.1.2 Emergency Response Plan

The Emergency Response Plan for the activity will be prepared by the hydraulic fracture program contractors and will be provided to DENR and DPIR and made available upon request. If the Emergency Response Plan is updated, a revised version will be provided to DENR and DPIR.

The emergency response arrangements within the Emergency Response Plan will be exercised early in the campaign to ensure that personnel are familiar with the plan and the type of emergencies to which it applies and that there will be a rapid and effective response in the event of a real emergency occurring. Following the exercise, lessons will be captured and the plan updated if required.

Other triggers for revising or updating the Emergency Response Plan may include:

- New information becomes available following an incident, near miss or hazard
- Learnings from an exercise or drill
- Change in contractor undertaking the work
- Organisational changes
- Changes to government agency contact details or portfolios

4.1.3 Well Operations Management Plan

Well Operations Management Plan (WOMP) will be submitted to the regulator for approval prior to spud of the first well activity to which the plan would apply. The WOMP will provide details on:

- Description of the well and well activities
- Well integrity risk management process
- Design, construction, operations and management of wells
- Performance outcomes
- Well lifecycle control measures
- Performance standards for control measures
- Performance objectives measurement criteria
- Monitoring, audit and well integrity assurance
- Well Abandonment and suspension considerations

- Responsibilities and competencies of contractors service providers
- Source control and blowout contingency measures

Fundamentally the risks of spills associated with the activity are managed effectively through the implementation of the mitigation measures described in Section 6 of the Hydraulic Fracture Program EMP. The impacts and risks associated with spills and leaks are well-understood and there are established practices in place to manage these risks. With the application of mitigation and management measures described in Section 6 of the Hydraulic Fracture Program EMP, the potential for chemical / fluid spills and leaks is reduced to an acceptable level.

4.2 Spill Detection

The hydraulic fracturing program will utilise a leak detection system designed to quickly identify the presence of leaks. The leak detection system includes the following:

- Each pond has two unperforated liners, plus a third liner that is connected to the leak detection system.
- Leak detection system is connected hydraulically via pipe work to a sunken leak detection system.
- If a leak is detected at the leak detection manifold, an audible alarm and flashing light will be activated.
- Alarm system will be connected via the flowback/welltest DAQ (data acquisition system) to ensure immediate response.
- Ponds manifolded to transfer water to pond with integrity should leak be detected, with transfer rates modelled.
- Leak detection manifold can be isolated if required, or to identify exact tank leak is coming from.
- Sufficient capacity in remaining pond(s) to transfer full contents of pond, if required.

Monitoring measures used to manage risk during the Hydraulic fracture program include:

- Hydraulic Stimulation fluids and flowback fluids are contained in engineered storage tanks within a bunded tank pad. These tanks and flowlines as a whole system will be monitored daily during the Hydraulic fracture program.
- Daily monitoring of weather and for predicted significant rainfall events will be undertaken
- Completion of the daily monitoring checklist
- Wellhead pressure monitoring (WOMP)

Other controls

- Spill kits are available at strategic locations at project site
- Emergency response training includes spill management techniques
- Freeboard designed into storage tanks
- Secondary containment of all stimulation and flowback fluid
- All produced water and flowback fluid must be stored in above-ground enclosed tanks

5.0 Spill Response Strategy

5.1 Response

Small spills will be managed using dedicated spill kits; which are readily available and appropriately stocked. For spills that are large, the Operating Company Representative is to notify the Santos D&C Superintendent as shown in the Detailed Emergency Response flowchart to provide incident details and initiate an appropriately response supported (See Figure 5-1).

All spills will be managed in accordance with:

- Santos Emergency Response Plan
- EWCRP – Emergency Well Control Response Plan for the Amadeus Basin and Beetaloo Basin
- Contractors ERP
- SMS-MS1 Risk – ST13 Environmental Hazard Controls Procedure
- Incident & Crisis ST2 - Incident Reporting, Investigation and Learning Procedure
- The EMP

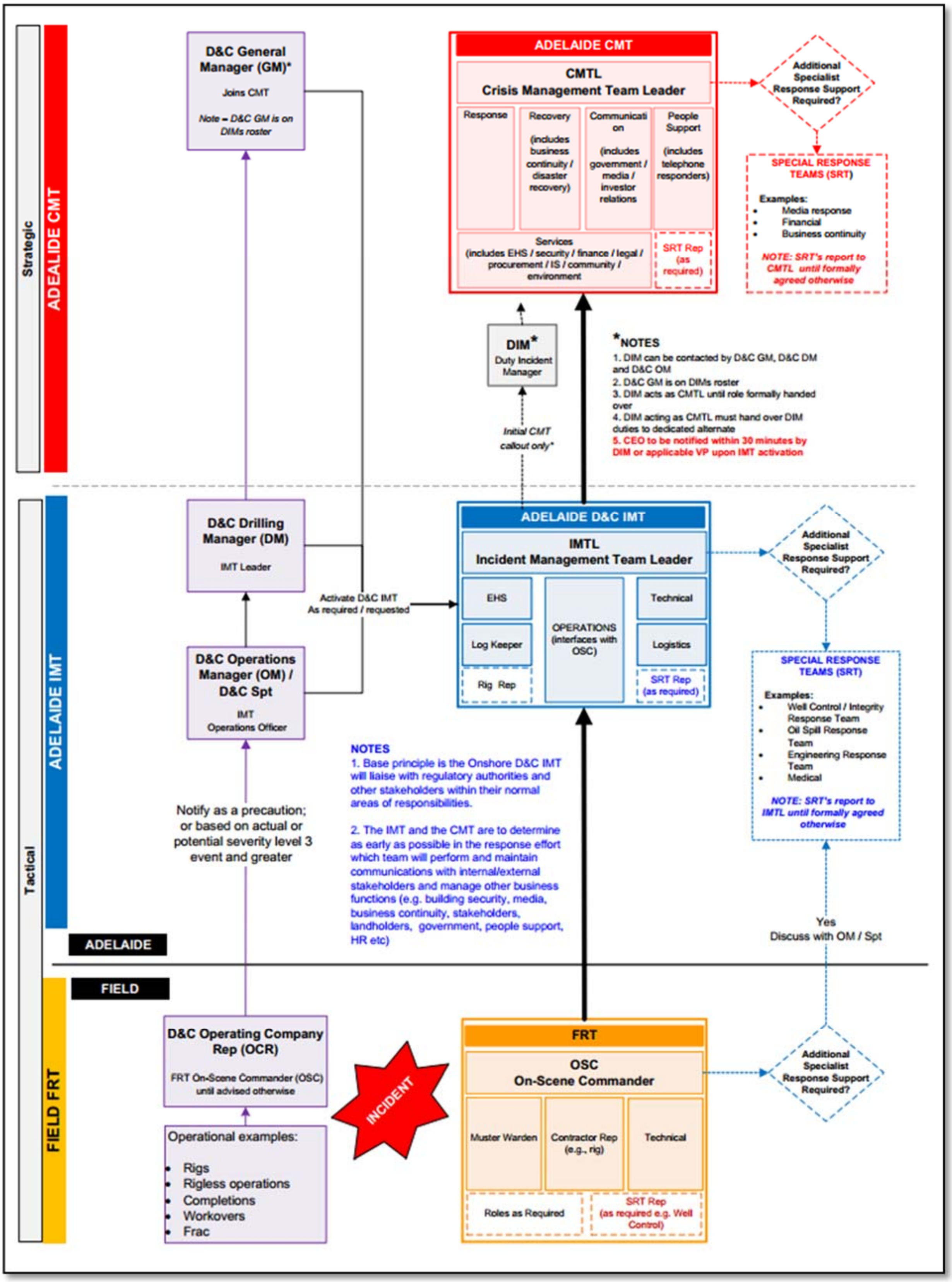


Figure 5-1 Detailed Emergency Response Arrangements

5.2 Communication Plan

5.2.1 Communication to Personnel

Spill prevention and monitoring strategies will be communicated to personnel working on the 2019 Hydraulic fracture program via:

- This Plan
- The EMP
- Site Inductions
- Safety Meetings
- Tool Box Talks
- Daily Meetings

Communications about a spill will be undertaken in accordance with the Emergency Communications section of the Emergency Response Plan. This includes the following steps:

- Incident Management Team Leader (IMTL) informed of incident and establishes contact with affected site to be provided with details of the incident, understanding of severity and response resource requirements
- Assessment of the emergency and severity is made (based on information from the affected site) and an emergency/incident response level determined
- IMT activated to provide support to the affected site or facilities
- D&C Superintendent attends the Incident Management Team (IMT) (where practicable) and liaises with IMTL to provide technical input and guidance
- IMTL maintains open communications with the affected site - On-Scene Commander (OSC)
- Affected site OSC supervises the Field Response Team (FRT)
- Other D&C personnel (roles) may be conscripted into the IMT as required

5.2.1.1 Wellsite Emergency Response Numbers (ERN)

Maintaining key well information and contact details is critical to ensure a timely response to an emergency. The aid in this Wellsite ERNs are provided for and available at each wellsite location include the following details:

- Name of the well
- Wellsite and camp site location coordinates and driving route
- Estimated travel distance to the nearest medical support
- Contact details for contractor personnel (mobile phone and satellite phone)
- Contact details of local Santos base (if relevant) and nearest emergency response support facilities

5.2.2 Petroleum (Environment) Regulations Incident Reporting and Recording

In the case of any inconsistencies the reporting requirement of the Petroleum (Environment) Regulations trump any requirements listed in this plan.

Spills will be reported to the minister in accordance with Part 3 of the Petroleum (Environment) Regulations. .

5.2.2.1 Notice of a reportable incident

Santos must give the Minister notice of a reportable incident in accordance with this regulation. A reportable incident means an incident, arising from a regulated activity that has caused or has the potential to cause material environmental harm or serious environmental harm. A notice of the reportable incident must be given to the Minister as soon as practicable but not later than 2 hours after the incident first occurred or if the incident was not detected at the time it first occurred – the time the interest holder became aware of the reportable incident.

Report about reportable incident

An initial report about a reportable incident will be given to the Minister as soon as practicable but not later than 3 days after the reportable incident first occurs; and must include comprehensive details about the following:

- the results of any assessment or investigation of the conditions or circumstances that caused or contributed to the occurrence of the reportable incident, including an assessment of the effectiveness of the designs, equipment, procedures and management systems that were in place to prevent the occurrence of an incident of that nature.
- the nature and extent of the material environmental harm or serious environmental harm that the incident caused or had the potential to cause
- any actions taken, or proposed to be taken, to clean up or rehabilitate an area affected by the incident
- any actions taken, or proposed to be taken, to prevent a recurrence of an incident of a similar nature

A report about recordable incidents must relate to each reporting period for the regulated activity and must be given as soon as practicable but not later than 15 days after the end of the reporting period. The report must contain:

- a record of all recordable incidents that occurred during the reporting period
- all material facts and circumstances concerning the recordable incidents that the interest holder knows or is able, by reasonable search or enquiry, to find out
- any action taken to avoid or mitigate any environmental impacts and environmental risks of the recordable incidents
- the corrective action that has been taken, or is proposed to be taken, to prevent similar recordable incidents.

Reporting will occur at a period agreed in writing between the interest holder and the Minister or each 90 day period after the day on which the environment management plan is approved.

Recordable incident means an incident arising from a regulated activity that has resulted in an environmental impact or environmental risk not specified in the current plan for the activity; or has resulted in a contravention of an environmental performance standard specified in the current plan for the activity; or is inconsistent with an environmental outcome specified in the current plan for the activity. A recordable incident is not a reportable incident.

Appendix I: Stakeholder Engagement Records

Table I-1: List of Relevant Stakeholders

Stakeholder	Role/Position	Phone number	Email or other contact
Aboriginal Affairs Protection Authority			
	Chief Executive Officer (CEO) AAPA		
Landholders/Managers			
	Insight Investments Porttfolio Director – Thames Pastoral		
	Tanumbirini Station Manager		
	Beetaloo / O.T Downs Station Manager		
	Broadmere Station Manager		
Northern Land Council			
	Manager Minerals and Energy		
Northern Territory Government			
	Executive Director – Onshore Gas Reform (DENR)		
	Executive Director (DPIR)		
	A/Director Onshore Petroleum		
	Senior Onshore Petroleum Advisor		
	Senior Environmental Onshore Petroleum		
	Regional Weed Officer (Onshore Shale Gas Development) – DENR		

Table I-2: Stakeholder Engagement Records

Stakeholder	Role / Position	Date	Type of Contact 9(1)f	Method of Contact	Matters Raised / Summary of Contact 9(1)c and 9(1)f	Copy of contact or information provided (if written) 9 (1)b. 9 (1)c	Written Responses Received 9(1)c	Trigger merit review 9(1)d	Statement of Santos' Response to Stakeholder (If required) 9(1)e	Details of the changes made to EMP 9(1)g
	Thames Pastoral	August and September	Email and phone calls	Consultation	Various discussion around water bore drill and water bore use - ongoing	N/A	No	No	None Required	None Required
	Emanate Legal/ Beetaloo and OT Downs Station	16/08/2019	Email and phone call	Consultation	Access request to Beetaloo/OT Downs Station for water bore baseline monitoring. Advised that Emanate legal would seek instruction and revert	N/A	No	No	Ongoing	None Required
	Thames Pastoral	15/08/2019	Email and phone call	Consultation	Correspondence and discussion around an information session for Thames Pastoral Directors and staff re Santos regulatory and environmental obligations	N/A	No	No	None Required	None Required
	Thames Pastoral	2/07/2019 22/07/2019 24/07/2019	Email	Consultation	Various logistics and operational discussions	N/A	Yes	No	Ongoing	None Required
	Thames Pastoral	20/06/2019	Email and phone hookup	LACA	Final LACA execution and discussion with Tom	See Attachment 1 and Attachment 2 of Appendix I	No	No	None Required	None Required
	Ward Keller	10/06/2019 13/06/2019	Email	LACA	Various correspondence re LACA for Santos 2019-21 operations on Tanumbirini Station prior to final execution	See Attachment 1 and Attachment 2 of Appendix I	Yes	No	Ongoing	None Required
	Thames Pastoral	6/06/2019	Phone hookup	LACA	Phone hookup to discuss LACA specifics before execution	See Attachment 1 and Attachment 2 of Appendix I	No	No	Ongoing	None Required
	Ward Keller	24/05/2019 27/05/2019 31/05/20196/06/ 2019	Email	LACA	Various correspondence re LACA for Santos 2019-21 operations on Tanumbirini Station	See Attachment 1 and Attachment 2 of Appendix I	Yes	No	Ongoing	None Required
	Thames Pastoral	20/05/2019	Phone hookup	LACA	Discuss various matters related to LACA	See Attachment 1 and Attachment 2 of Appendix I	No	No	Ongoing	None Required
	Thames Pastoral	16/05/2019	Email	LACA	Discuss various matters related to LACA	See Attachment 1 and Attachment 2 of Appendix I	Yes	No	Ongoing	None Required
	Ward Keller	3/05/2019 7/05/2019 15/05/2019	Email	LACA	Various correspondence re LACA for Santos 2019-21 operations on Tanumbirini Station	See Attachment 1 and Attachment 2 of Appendix I	Yes	No	Ongoing	None Required

Stakeholder	Role / Position	Date	Type of Contact 9(1)f	Method of Contact	Matters Raised / Summary of Contact 9(1)c and 9(1)f	Copy of contact or information provided (if written) 9 (1)b. 9 (1)c	Written Responses Received 9(1)c	Trigger merit review 9(1)d	Statement of Santos' Response to Stakeholder (If required) 9(1)e	Details of the changes made to EMP 9(1)g
	Thames Pastoral	30/04/2019	Face to face	LACA and various	Meeting in Darwin to discuss key LACA considerations and various other Santos/TPC related matters	See Attachment 1 and Attachment 2 of Appendix I	No	No	Ongoing	None Required
	Thames Pastoral	24/04/2019	Email	LACA	Discuss various matters related to LACA	See Attachment 1 and Attachment 2 of Appendix I	Yes	No	Ongoing	None Required
	Ward Keller	23/04/2019	Email	LACA	Various correspondence re LACA for Santos 2019-21 operations on Tanumbirini Station	See Attachment 1 and Attachment 2 of Appendix I	Yes	No	Ongoing	None Required
	Broadmere Station	19/04/2019	Phone call	Consultation	General up of Santos activities in the area	N/A	No	No	Ongoing	None Required
	Ward Keller	5/04/2019	Email	LACA	Various correspondence re LACA for Santos 2019-21 operations on Tanumbirini Station	See Attachment 1 and Attachment 2 of Appendix I	Yes	No	Ongoing	None Required
	Thames Pastoral	27/03/2019	Face to Face	LACA	Meeting with Thames Pastoral's external lawyer and also a Thames Pastroal Director to discuss various including LACA	See Attachment 1 and Attachment 2 of Appendix I	No	No	Ongoing	None Required
	Thames Pastoral	22/03/2019	Email	LACA	Draft LACA received from Thames Pastoral for Santos proposed 2019-21 activiies	See Attachment 1 and Attachment 2 of Appendix I	Yes	No	Ongoing	None Required
	Thames Pastoral	15/03/2019	Email	LACA	Advice from Thames Pastoral re their external legal representative for LACA negotiations	See Attachment 1 and Attachment 2 of Appendix I	Yes	No	Ongoing	None Required
	Thames Pastoral	8/03/2019	Email	LACA	Compensation assessment report undertaken by Santos provided to Thames Pastoral and further information on Santos proposed water use vloumes	See Attachment 1 and Attachment 2 of Appendix I	Yes	No	Ongoing	None Required
	Thames Pastoral	27/02/2019	Email	LACA	Further corresponsence re LACA negotiations	See Attachment 1 and Attachment 2 of Appendix I	Yes	No	Ongoing	None Required
	Thames Pastoral	25/02/2019	Email	LACA	Further corresponsence re LACA negotiations	See Attachment 1 and Attachment 2 of Appendix I	Yes	No	Ongoing	None Required
	NLC Manager Minerals and Energy	16/01/2019	Email	Work Program	In accordance with clause 5.1(c) of the EP 161 Co-operation and Exploration Agreement Santos provided a Work Program (Northern Scope) and supporting spatial files with respect to areas within EP 161 where it proposes to undertake activities. (Full Program provided Below)	See Attachment 3 of Appendix I	Yes	No	Ongoing	None Required

Stakeholder	Role / Position	Date	Type of Contact 9(1)f	Method of Contact	Matters Raised / Summary of Contact 9(1)c and 9(1)f	Copy of contact or information provided (if written) 9 (1)b. 9 (1)c	Written Responses Received 9(1)c	Trigger merit review 9(1)d	Statement of Santos' Response to Stakeholder (If required) 9(1)e	Details of the changes made to EMP 9(1)g
	NLC Manager Minerals and Energy	26/04/2019	Email	Communication	EP 161 Enabling Activities 2018: Report to AAPA and Summary Report to Operator	AAPA Certification provided to DENR	Yes	No	Ongoing	None Required
	NLC Manager Minerals and Energy	10/05/2019	Email	Communication	Santos - Certificate for Variation to C2014/053 over EP 161 Northern Areas (AAPA ref: 201900379)	AAPA Certification provided to DENR	Yes	No	Ongoing	None Required
	NLC Manager Minerals and Energy	17/06/2019	Email	Communication	Informing NLC of Notice of EMP Approval	AAPA Certification provided to DENR	Yes	No	Ongoing	None Required

NOTE: Daily communications were undertaken with the Tanumbirini Station Manager which included face to face, email and phone call. A Santos Land Access Field Supervisor has been present and will be present on the property during Santos drilling and associated activitie to manage Santos day to day interactions with Tanumbirini Station.

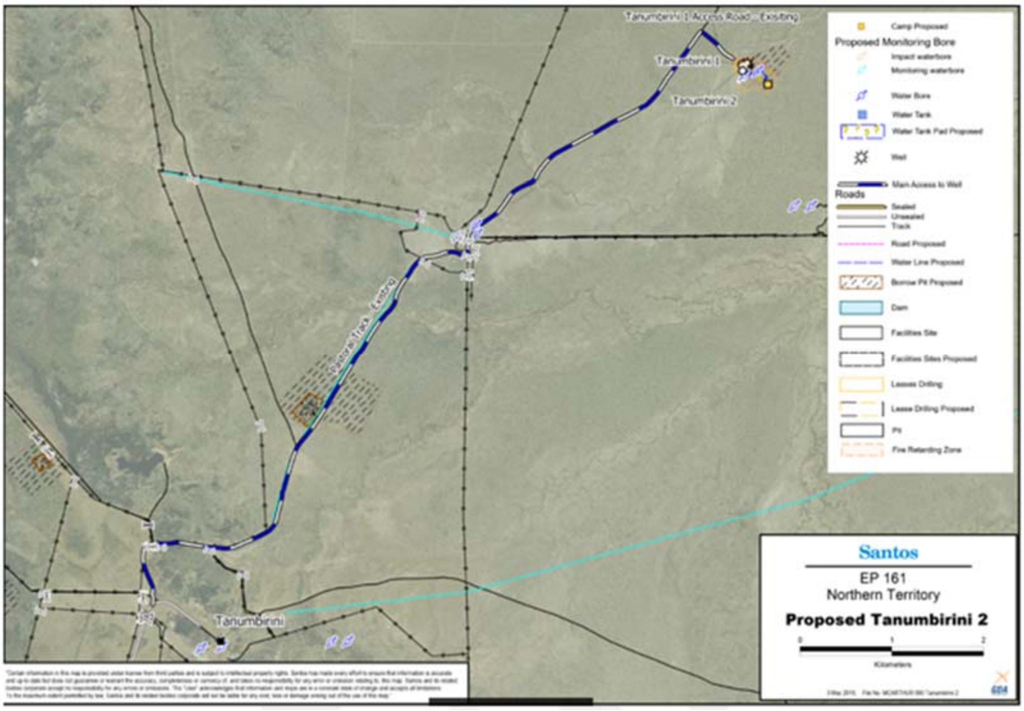
Attachment 1- Pastoral Land Access and Compensation Agreement – Confirmation Email (Commercial in Confidence)

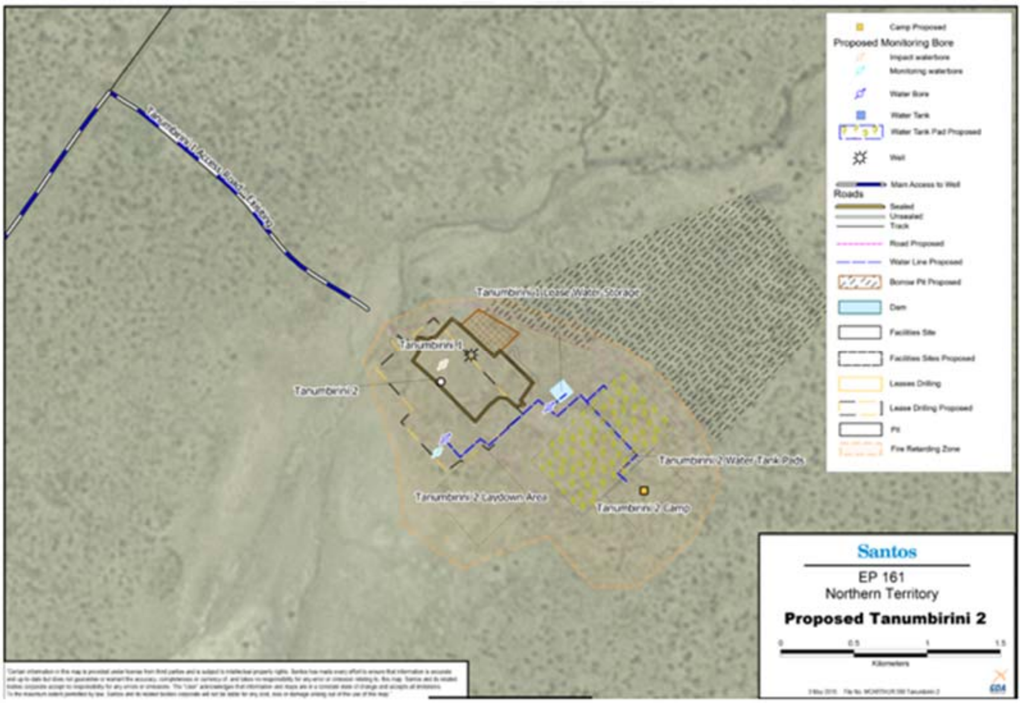
Page Redacted

Page Redacted

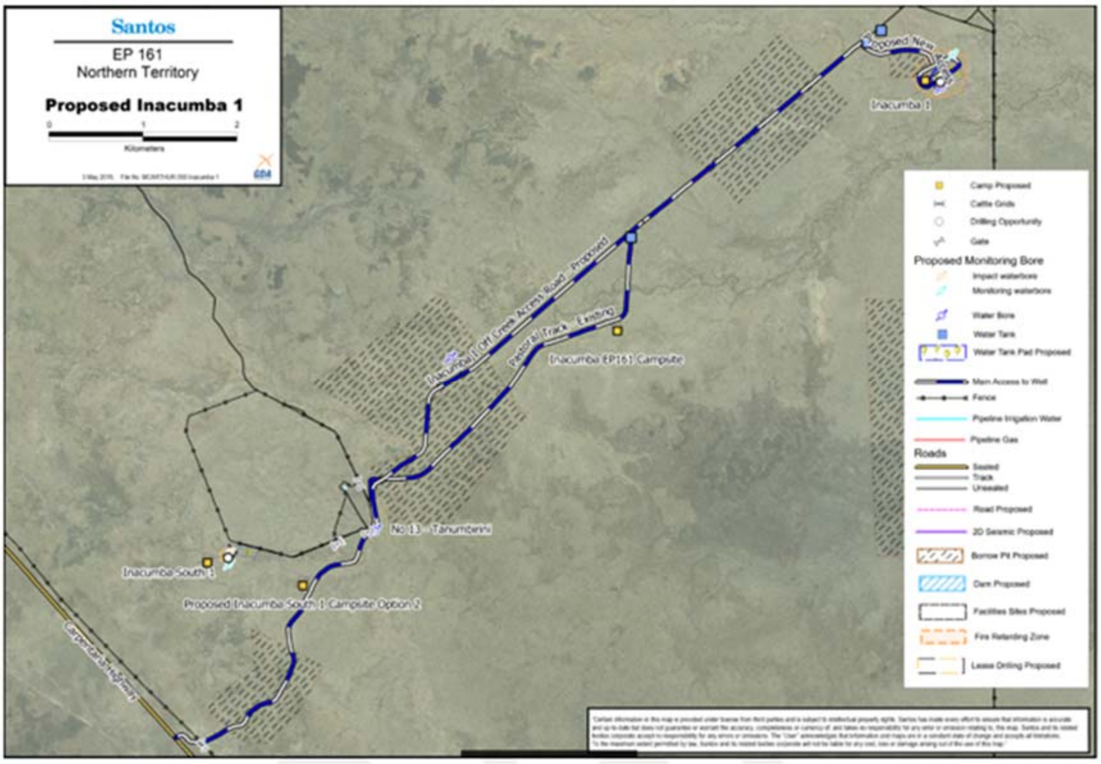
Attachment 2- Pastoral Land Access and Compensation Agreement – Annexure D Plans

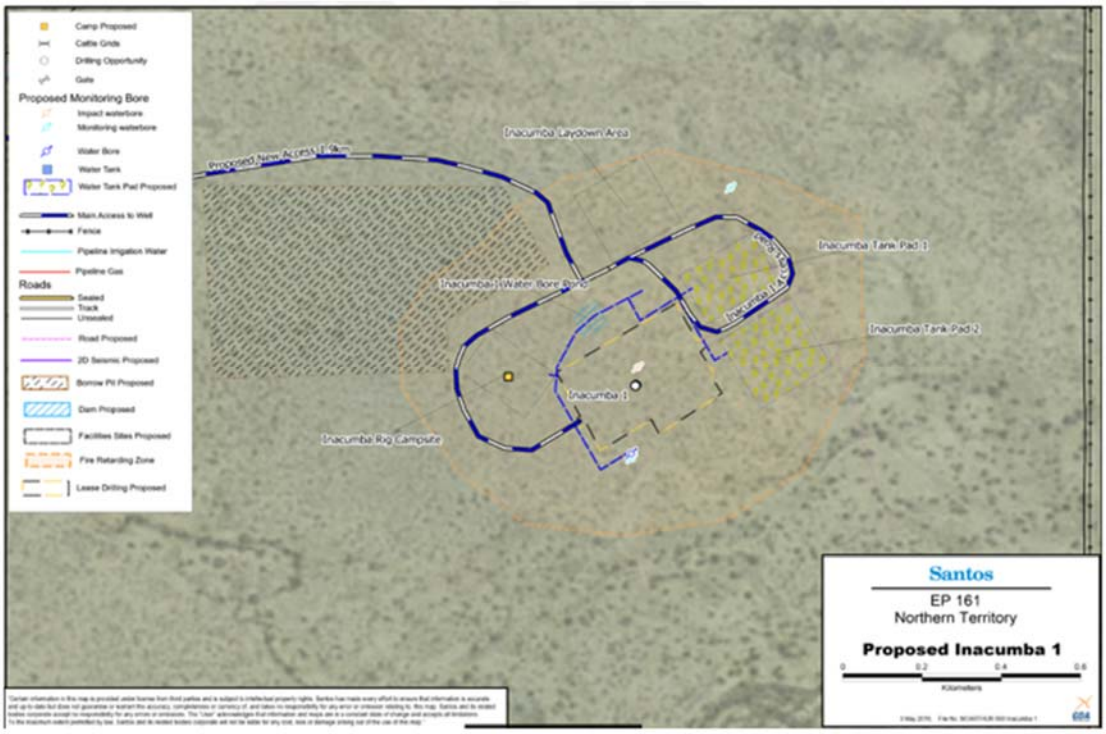
__Tanumbirini #2 access road and wellsite maps__



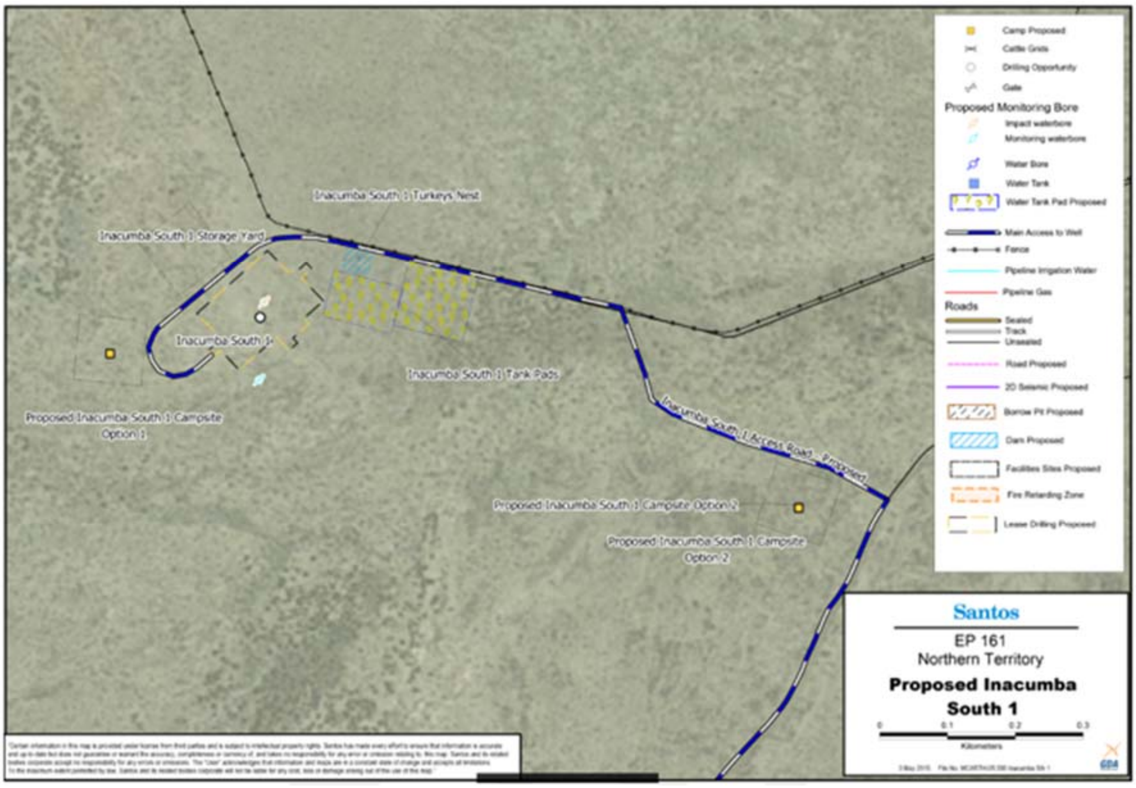


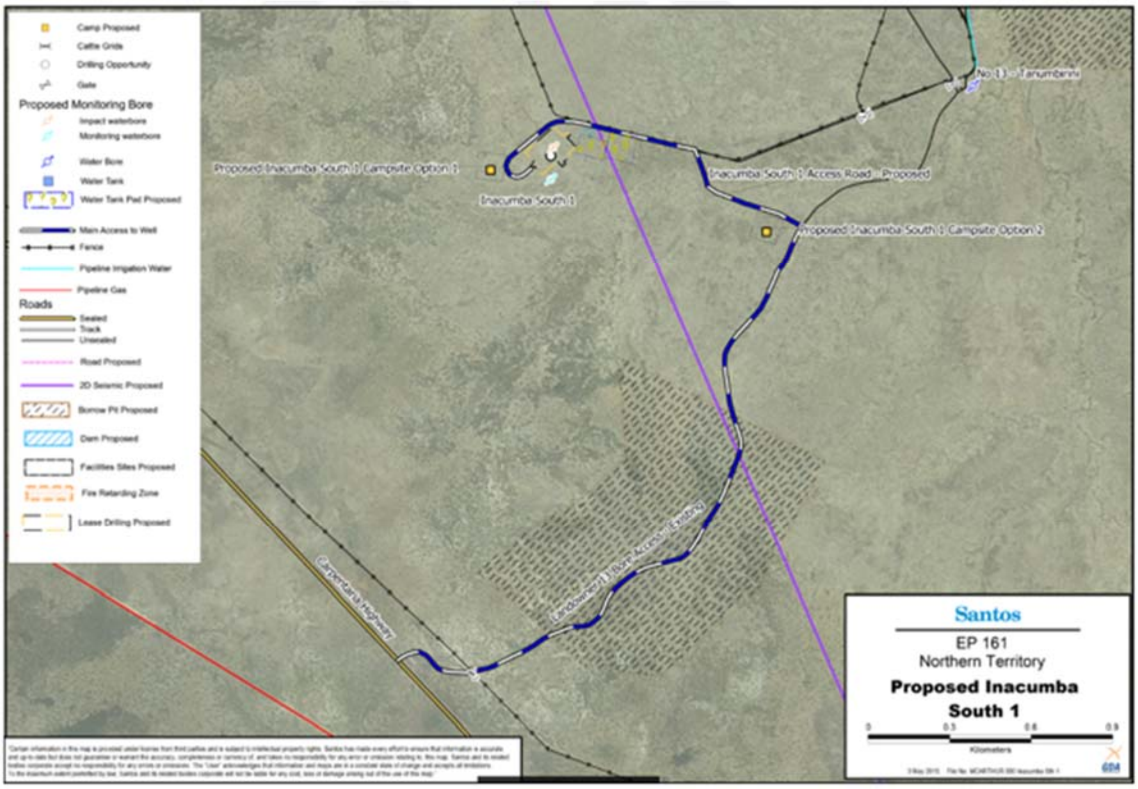
Inacumba #1 access road and wellsite maps



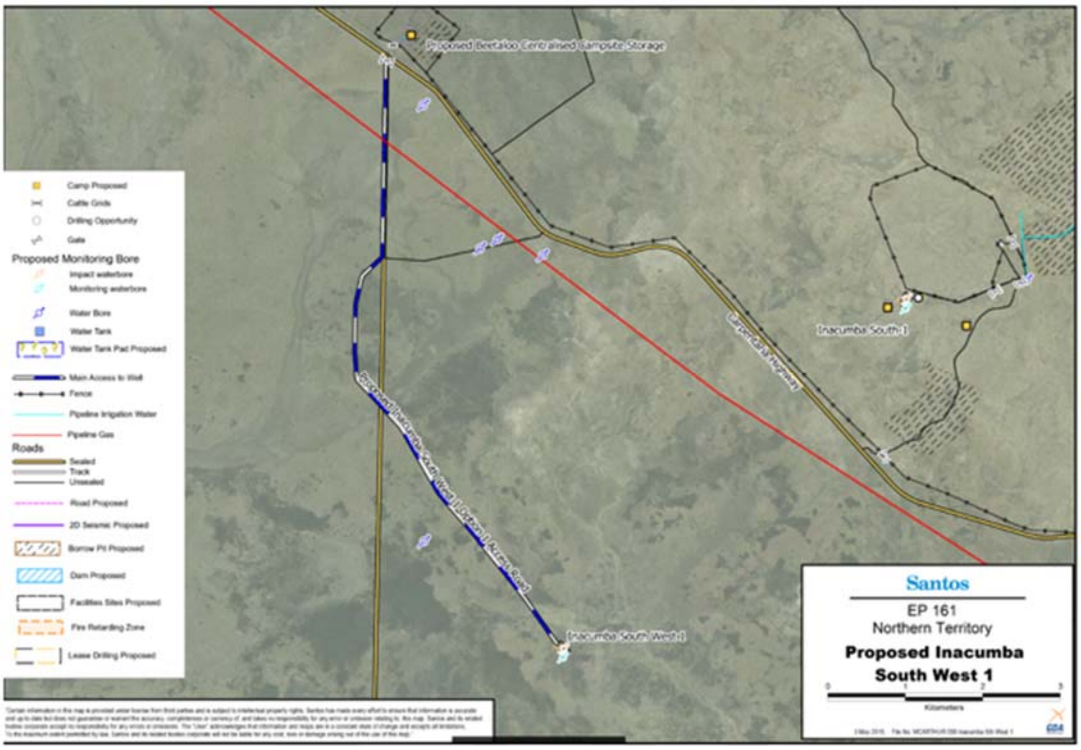


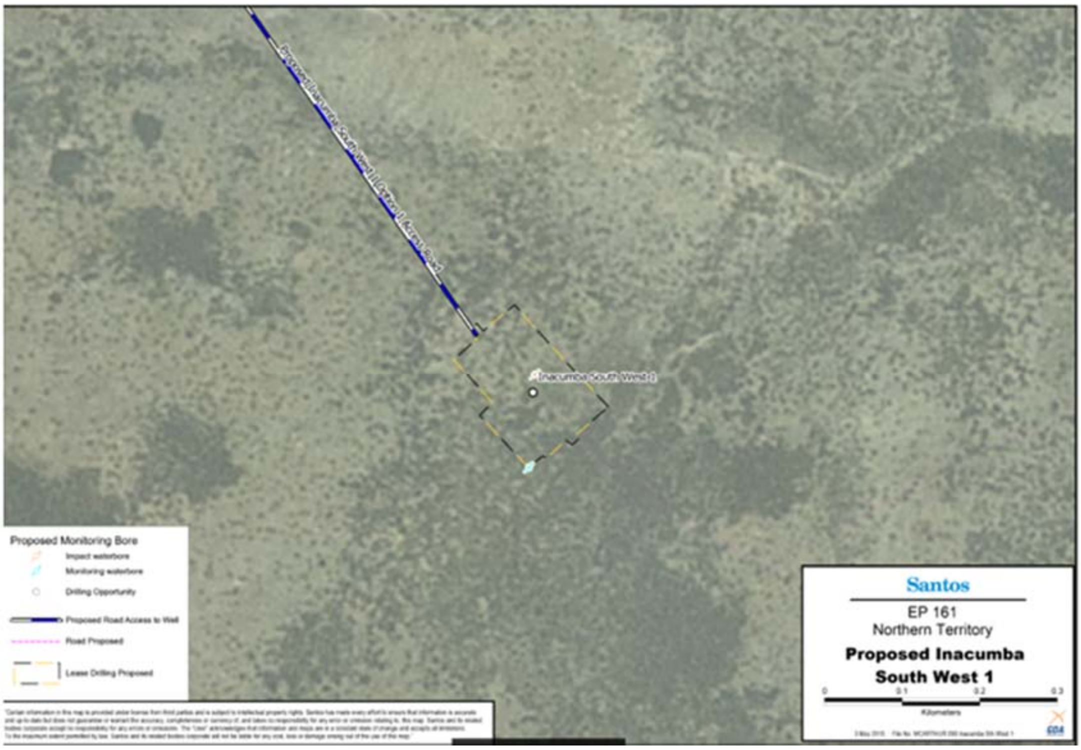
Inacumba South #1 access road and wellsite maps



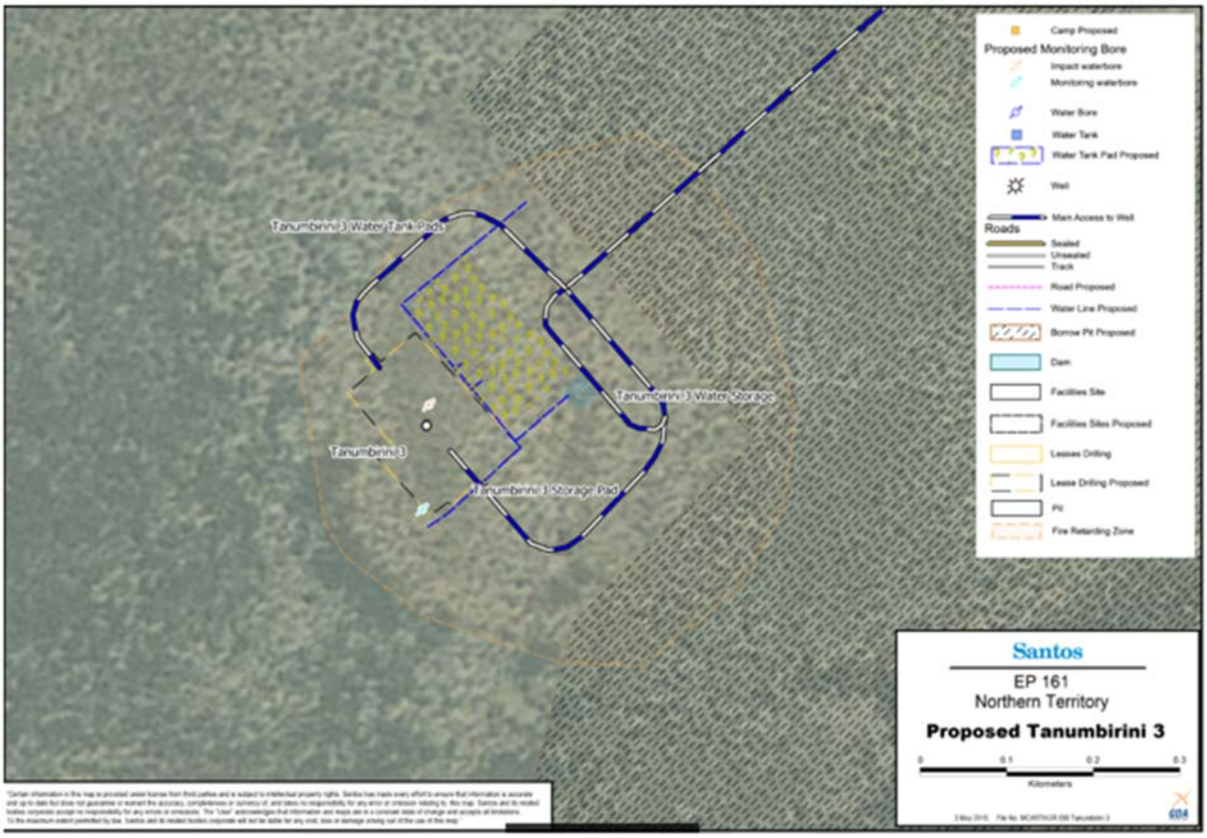


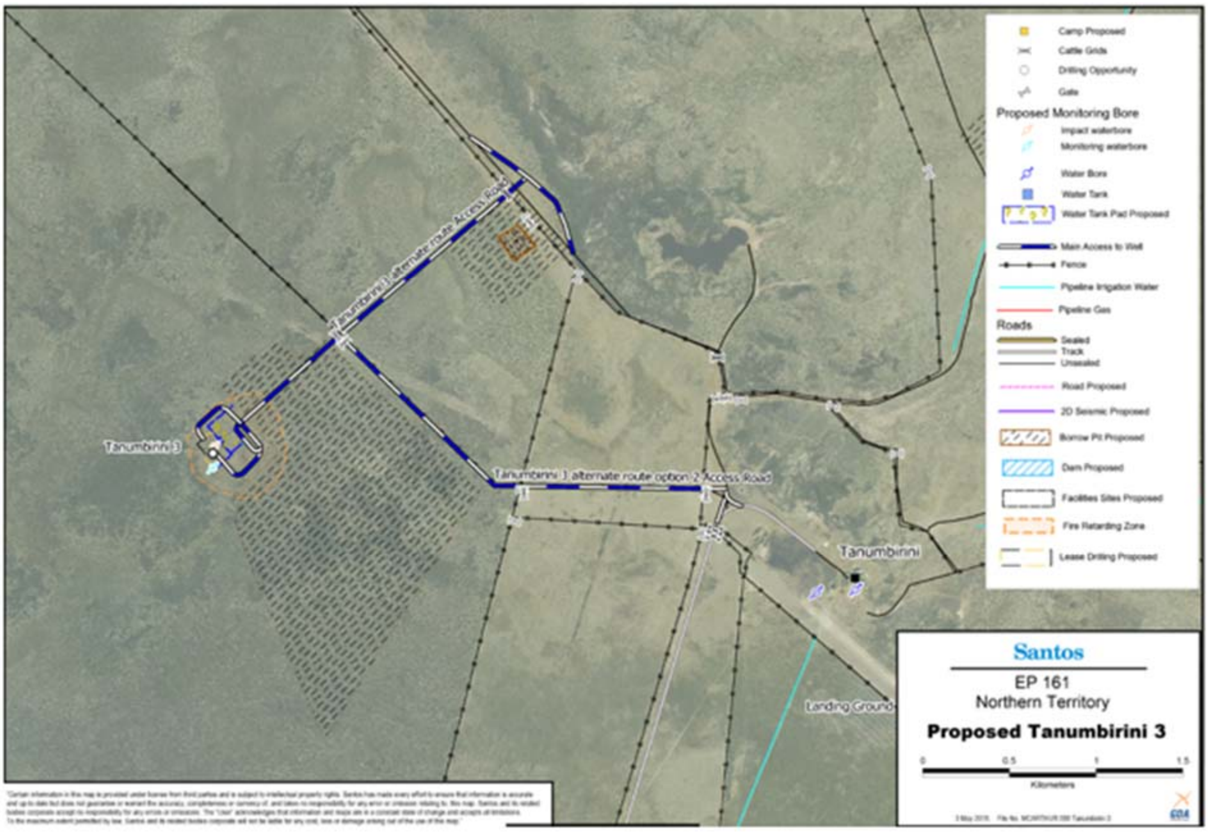
Inacumba South West #1 access road and wellsite maps





Tanumbirini #3 access road and wellsite maps





2D seismic line between Tanumbirini #2 and Inacumba South #1

Attachment 3- NLC Submission

Santos Ltd
ABN 80 007 550 923
Ground Floor Santos Centre
60 Flinders Street
Adelaide SA 5000
GPO Box 2455 Adelaide SA 5001
Telephone: 08 8116 5111

WP-19-0002
15 January 2019

CONFIDENTIAL – Commercial in Confidence

Attention: Native Title
Parties Representative
C/o Northern Land Council
45 Mitchell Street
Darwin NT 0800

Mr. Malcolm Hauser
Senior Project Officer
Borroloola - Barkly Region
Minerals and Energy
Northern Land Council
45 Mitchell Street, Darwin NT 0801

Dear Malcolm,

WP-19-0002_EP 161_McArthur_2019_Work Program – Northern Scope

Santos (QNT) Pty Ltd (Santos), in accordance with clause 5.1(c) of the Co-operation and Exploration Agreement, EP 161, provides this Work Program with respect to areas within EP 161 where it proposes to undertake activities. The areas identified in this submission (Tanumbirini North and Inacumba North; or collectively the **Northern Locations**) are identical to those submitted, and subsequently surveyed by the NLC and Traditional Owners, in 2013/14 and resulted in an Anthropological Report being provided to AAPA and the attached AAPA Authority Certificate C2014/053 being issued. These locations were also surveyed more recently in late 2018, although for the purpose of drilling water bores rather than exploration wells; these activities are covered by AAPA Authority Certificate C2018/105.

Many of the activities included in this submission, such as exploration drilling, have therefore, been the subject of previous sacred site surveys. These areas have also been the subject of previous surveying associated with seismic activity undertaken in 2013 (Authority Certificate C2013/142).

This submission includes further activity at the previously surveyed Northern Locations, as outlined in summary below and in detail in the attached tables and annexures. We request the opportunity to inform the host Traditional Owners via a community consultation and for the host Traditional Owners to review the Northern Locations (and their access routes) via a remote mapping exercise given the extensive and recent sacred site surveys. Noting the timeframes to undertake work in 2019 any assistance in expediting the process for the Northern locations would greatly assist the planned 2019 exploration program.

In parallel to this submission, Santos will also submit a work program for identical activity clearances at two locations (Tanumbirini South and Inacumba South; collectively the **Southern Locations**) where water bore installation has recently been approved but approval for exploration drilling has not previously been sought via the work program process. We understand that approvals for the Southern Locations are unlikely to be able to be expedited given that they will likely require sacred site surveys following the 2018-19 wet season along with community consultation.

Scope (Northern Locations)

Approved by and entirely within the areas included in Authority Certificate C2014/053 and Authority Certificate C2018/105:

- Civil engineering activity – upgrading and creation of new access tracks, lease pads, water bore installation and water extraction as required (note that water extraction will require a Water Extraction License)
- 2D seismic acquisition

New activities for approval in the areas included in Authority Certificate C2014/053 and Authority Certificate C2018/105:

- Civil engineering activity – upgrading and creation of new access tracks, lease pads, water bore installation and water extraction as required (note that water extraction will require a Water Extraction License)
- 2D seismic acquisition
- Exploration drilling – both vertical and horizontal drilling (where horizontal wells will be contained entirely within the 5km radius subject area)
- Well evaluation – including wireline logging, formation testing, core acquisition, fluid sampling, open-hole formation integrity testing (i.e. DFITs) and other standard oilfield evaluation techniques as deemed appropriate
- Hydraulic fracture stimulation
- Flow-back and production testing
- Well suspension and/or well decommissioning
- Ongoing site and well maintenance and monitoring, work-over and re-entry, and evaluation as required

Details of the proposed project work activities are included in the attached tables and annexures, and have been identified by undertaking a combination of desktop assessment and information from locations previously scouted.

Purpose

The purpose of exploration and appraisal activity undertaken at the Northern Locations in 2019, 2020 and beyond is to increase our understanding of the prospectivity or potential of the EP161 permit area. Our objective whenever undertaking such activity is to minimise our impact on the environment, including any activities of Traditional Owners and pastoral lessees.

AAPA Authority Certificate

Santos will seek an Authority Certificate from Aboriginal Areas Protection Authority (AAPA). As previously agreed and discussed, the NLC will undertake the on ground assessment remote assessment and provide the report findings to AAPA in the AAPA template which has been previously provided.

Work Program Meeting

Santos is available to attend work program meetings on country or, in the absence of a work program meeting, resource the NLC accordingly to meet any community requirements. Santos is willing to fund and resource interpreters or any other specific requirements to meet community requirements.

Well Locations and Coordinates

Refer to the attached maps, spatial data and the table below for the coordinates of the proposed project works, including access.

Attachments

Please refer to the attachments which contain maps, spatial data, tables and descriptions of the proposed activities proposed at each location with approximate coordinates of the proposed well locations under application:

1. Attachment 1: Summary table, maps, tables of proposed work activities and locations.
2. Attachment 2: Annexures describing industry work activities
3. Attachment 3: GIS data and supporting imagery

Santos is seeking your approval to proceed on this basis and look forward to meeting at an agreed date to discuss in detail and progress this work program.

Santos also notes the importance of the community consultation requirements to ensure the host traditional owners are adequately consulted and informed of project activities. We look forward to working with the NLC to ensure the community consultations fully inform the host traditional owners.

Please contact Che Cockatoo Collins on the details below if you require any further information or clarification of the proposed works.

Kind regards,

Che Cockatoo Collins – Access Adviser Aboriginal Engagement che.cockatoo-collins@santos.com

David Close - Exploration Manager – Onshore NT, QLD & NSW David.Close@santos.com

Attachment 1 – EP 161

1. Summary of proposed activities

All of the activities included in Table 1 and annexures are subject to extensive regulatory approvals or review by the Department of Primary Infrastructure and Resources, the Department of Environment and Natural Resources, the Environmental Protection Authority, and other regulatory agencies. Moreover, substantial baseline data acquisition (including water monitoring bores installed at least six months prior to drilling hydraulic fracture stimulation activity) is required under the Petroleum Act and associated Petroleum Environment Regulations. Further details regarding these approvals and or approval submissions can be provided on request.

Table 1. Summary of the Proposed Work Program

(A) The nature, scope and objectives of proposed activities;	Please refer to Annexures for detailed descriptions of the exploration activities summarised in this table, which include 2D seismic, exploration drilling, hydraulic fracture stimulation, flow-back and production testing, well monitoring and site maintenance, and associated civils works. The annexures detail the following activities that could potentially be proposed at both the Tanumbirini North and Inacumba North locations: • 2D seismic acquisition (Annexure 1) • Wellsite civils works, access and camps (Annexure 2) • Diagnostic Fracture Injectivity Testing (DFIT) (Annexure 3) • Exploration drilling and evaluation (Annexure 3) • Microseismic and tiltmeter monitoring (Annexure 3) • Fracture stimulation (Annexure 3) • Flow or production testing (Annexure 3) • Completion including suspension and/or well decommissioning (Annexure 3) • Ongoing well and site monitoring, maintenance, work-over and evaluation Refer to the provided maps and spatial data for proposed locations, access, and approximate areas of disturbance. All proposed work activities will be located within the boundaries of the AAPA Authority Certificates C2014/053 and C2018/105.
(B) The estimated time and period for the performance of such activities;	It is proposed that seismic and civils activity could commence as early as Q2 2019 and that drilling activities could commence in late Q2 2019. However, activity commencement will require substantial approvals and it is possible some or all activity will be deferred until 2020. Activity could be repeated in future years at these locations pending appropriate notification and discussion by Traditional Owners through On Country Work Program meetings. **The following summarises typical time-frames for discrete work packages or activities and reflects the planned 2019 or 2020 (pending approvals) work program plan. In future years, timings could vary and activity**

	could reduce. It is unlikely that 2D seismic acquisition will be repeated and, once access and a well lease is constructed, these activities will not be repeated (although maintenance will be required). **4-12 weeks – Lease and Access Track Preparations:** Access track preparation, well pad construction and associated works will be undertaken in preparation for drilling operations. Where possible existing access tracks will be upgraded; however, new access tracks will be created (within the surveyed areas only) if it achieves the objective to minimise the overall impact of the operations. Temporary camps will be used to support these activities. **2-8 weeks – Seismic Acquisition (well focused not regional surveying):** Line preparation and surveying typically takes 1-2 weeks depending on the extent of the survey. The seismic recording crew then typically commence 1-2 weeks after line preparation and surveying crews and will typically take a further 1-2 weeks to complete the seismic survey. The extent of any surveying that could be considered under this clearance request is relatively limited as it will be contained within the 5km radius buffer around the well lease. **60-90 days (per well) – Drilling Phase:** Following completion of lease and access track preparations, the drilling phase is anticipated to take approximately 60-90 days per well. **15-40 days (per well) – Fracture Stimulation Phase:** Following completion of drilling and well completion, the fracture stimulation phase is anticipated to take approximately 15-25 days per well. **3-5 days (per well) – Completion Phase:** Pending the initial gas flow rates, wells may be completed with a tubing string that is run in the well to improve productivity. The tubing will be installed with a workover rig and is anticipated to take approximately 3-5 days per well. **Flow Testing Phase and Well Suspension:** Subject to a successful reservoir outcome, the well will be put on extended flow test for an initial period of approximately 90 days. We will seek approvals to extend the flow testing period for one or more years from the Northern Territory regulator for early exploration wells to allow key data to be gathered. Flaring will be used to ensure hydrocarbon gases are safely and efficiently handled. Such approvals will be subject to rigorous environmental management plan approvals. Subsequent to any flow testing the well will be suspended. A build-up test may be incorporated into the well suspension to aid in the evaluation of the well results. Following the build-up test a successful test well will likely be suspended until a development project is sanctioned or a well is decommissioned at the end of the project life.

	Further on-going well integrity monitoring, well-head maintenance, site maintenance, in-hole evaluation and work-over will be performed as required. If required, Santos will provide further details prior to the field work and as planning progresses
(C) The techniques, infrastructure and major items of equipment to be used;	**Civils Surveying:** Surveying of proposed access tracks, leases, gravel/borrow pits, camp sites and associated facilities will be carried out using 4WD vehicles and GPS units utilising existing roads and station tracks where possible. **Road Construction:** Existing access roads and tracks will be upgraded and widened (within approved subject land area only) to accommodate larger vehicles and the drilling rig mobilisation to well site. New access roads or tracks will be created where necessary to access the lease pad or minimise our overall environmental impact or impact on pastoral lessee infrastructure or activities. The attached maps (Attachment 1) and spatial data show the locations of the proposed access tracks based on previous scouting and authority certificate subject lands. All proposed access tracks are within the clearance area of the C2014/053 Authority Certificate and/or the C2018/105 Authority Certificate. Changes to these proposed routes may occur to minimise overall impact; however, at no times will the surveyed area previously approved by Traditional Owners (via the NLC) and AAPA (under C2015/053 and C2018/105) be exceeded. **2D Seismic Acquisition:** Refer to Annexure 1 for details of the 2D seismic survey process **Well Pad / Lease Construction:** Well lease construction will include clearing and stockpiling, grading and capping with clay/suitable material if deemed required based on ground condition. Construction of turkey's nests and above ground storage tanks will occur if required. Stockpiled vegetation and top soil will be respread as part of the rehabilitation process, following well decommissioning (which may be some or many years in the future depending on exploration and appraisal activities and project success). **Drilling Activities:** The wells will be drilled using either drilling mud or air hammer as required to suit formation properties. Wells will be either vertical only (i.e. a vertical well), or initially vertical with a subsequent inclined section leading to a lateral or horizontal section (i.e. a deviated or horizontal well). Vertical well sections could vary between approximately 1000m and 4500m and horizontal sections could vary from less than approximately 250m to in excess of 3000m (where the absolute limit of any horizontal well

	would be the area surveyed and cleared for sacred sites (i.e. the clearance area). Where possible, drill core and/or cutting samples and/or fluid samples will be obtained for geological assessment and analyses as per Santos and regulatory requirements. **Evaluation Activities:** Open-hole wireline logs will be acquired over the open-hole sections as per Santos and Northern Territory Government requirements. In addition to wireline logging Santos may undertake formation testing, open-hole formation integrity testing (i.e. DFITs) and other standard oilfield evaluation techniques as deemed appropriate. Vertical seismic profiling may also be completed, this activity combines surface seismic activities (Annexure 1) with down-hole wireline evaluation tools (geophones). **Diagnostic Fracture Injection Test (DFIT):** A DFIT refers to the act of injecting small volumes of a clear fluid, typically water (usually with a small percentage of Potassium Chloride e.g. 2 to 3% KCl) at low pumping rates to create a fracture before the wellhead is shut-in and the pressure allowed to fall-off naturally. The fluid contains no proppant so that the fracture can relax and close naturally when pressure is released. The pressure changes are measured with high-accuracy gauges that are either placed deep in the wellbore or at surface on the wellhead. The analyses of fracturing pressure, during injection and after shut-in, provide information data for understanding and improving the fracturing process. The DFIT process differs from fracture stimulation in a number of key ways, primarily it is of a much smaller scale, does not involve pumping proppant, and is not intended to induce hydrocarbon production. **Well Completion Activities:** The wells will have casing set in the well to meet the design objectives of the well and the meet the standards from the NT Well Operations Code of Practice and the Santos Drilling and Completions Management Process (DCMP). Casing will be set in order to isolate shallow aquifers present, isolate any geohazards that may present like significant formation losses or tight hole, as well as being designed to withstand the expected forces during hydraulic fracturing. Each casing string will be cemented in place to ensure aquifer isolation and overall wellbore integrity is maintained. Once each casing is cemented in place, it is pressure tested to ensure the cement and casing meet and/or exceed their design specifications. The final casing string, the production string, is tested to above the maximum anticipated pressure to stimulate and confirm the integrity of the designed well envelope. **Hydraulic Fracture Stimulation Activities:** Prior to the hydraulic fracture stimulation (or frac) “spread” (the term used to describe the various trucks and equipment needed to frac) arriving on location, the well will be logged to confirm the cement bond and ensure isolation between the fracture stimulation target intervals and shallow aquifers. A number of valves are

installed on the wellhead known as the “Christmas Tree” which are rated to above the maximum designed surface pressure, and allow for the transfer of fluid and proppant/sand into the wellbore. The complete system is then pressure tested again to simulate hydraulic fracturing conditions.

Intervals to be fracture stimulated will be perforated using a shaped charge which creates small holes in the casing providing a conduit between the wellbore and the formation. The combination of water, proppant and chemicals (generally <2% of total mix) known as the slurry are mixed together at surface using a “blender” – see Annexure 4 for summaries of the chemical composition of potential frac fluids and solids that could be included, and note that they are typically used at low concentrations (the final fluid composition must be provided to the NT Government as part of the environmental approval process). The slurry is transferred to pumps that convert it from low pressure to high pressure, and allow it to be injected through the wellhead into the well, and ultimately into the formation that is being hydraulically fracture stimulated. After each frac stage, a plug is pumped down on wireline and the next frac stage is perforated, and the process starts again.

At the completion of hydraulic fracturing, Coiled Tubing is used, which is run in hole with a motor and mill on the end to remove the isolation plugs in place. After reaching the bottom of the well with the coiled tubing and establishing a flow path to the surface for all frac stages, the well flowback commences in order to recover the frac fluids pumped into the well.

Fracture Diagnostics are often used to determine the fracture effectiveness and allow for future optimisation. Chemicals Tracers may be pumped with the slurry at a known concentration. Their concentration during flowback can be measured to determine the relative contribution from each stage. Microseismic geophones may be used either at surface or in a neighbouring well, to listen for the very small seismic events that are created during fracture stimulation. Triangulation is used from the geophone array to determine the location of the event and hence gain a picture for fracture dimension (height and length) and direction. Tiltmeters may be used to gain an understanding of the micro deformation that takes place during a frac. These small changes can be used to determine the verticality of the frac and also indicate the direction in which the fracture has propagated. The installation of either surface geophones or tiltmeters is low-impact, and down-hole geophones have no impact on the environment.

Flow-back and Well Testing Activities:
Some flow testing may be conducted with the drilling rig on location prior or post open hole logging activities.

Subject to a successful reservoir outcome, wells will be flow tested for an initial period of approximately 90 days.

	We will seek approvals to extend the flow testing period for one or more years from the Northern Territory regulator for early exploration wells to allow key data to be gathered. Flaring will be used to ensure hydrocarbon gases are safely and efficiently handled. Such approvals will be subject to rigorous environmental management plan approvals. **Well Status:** Exploration wells in the McArthur/Beetaloo area are exploration wells with relatively high uncertainty on reservoir outcome. The following activities may occur post logging evaluation: 1. The well will be suspended with steel casing cemented in place for future re-entry; or 2. The well will be decommissioned. As part of the well suspension process, wellbore barriers will be put in place as per Santos and Northern Territory regulatory requirements. A well integrity monitoring plan will be put in place for any suspended well for monitoring of wellbore barriers. As part of well decommissioning process, cement plugs will be permanently placed in the well as per Northern Territory regulatory requirements. The wellhead will be removed; leases and roads rehabilitated and signed properly as per Northern Territory regulatory requirements. **Site Rehabilitation Activities:** For any decommissioned well, the well pad and associated camp sites, etc. will be rehabilitated to ensure minimal disturbance. For any suspended well, the wellhead area will be fenced off and the well pad site rehabilitated as much as practical to ensure re-entry for well integrity monitoring and intervention activities can be maintained. Further technical details can be provided on request. **Camps** Camps may be constructed within the approved subject lands to support the above activities. These camps may be capped with suitable clay material if required based on ground conditions. Preference will be given to utilising previously disturbed areas. All camps will be covered by a valid Environmental Management Plan and comply with all conditions of that plan to minimise environmental impacts.
(D) The likely Environmental Impact of such activities and proposals to minimise the Environmental Impact, in particular, the disturbance to Native Title Parties;	Where possible, access roads, borrow/gravel pits, leases, camp sites and associated works will be planned so as to use existing station roads and/or access roads or resources to minimise any new disturbance. Access tracks planned to be utilised have been identified from initial scouting activities. Where it is not possible to use existing

	tracks and access roads, due to the requirements of heavy vehicle access (where upgrading of the existing track is not feasible), some new access tracks will need to be constructed. New access tracks will not exceed the approved subject lands in the authority certificates referenced above. Roads/access tracks could extend up to 10m either side of centre line (i.e. up to 20m in width). Where possible and practical new access tracks will be oriented to minimise or avoid disturbance to land systems and native flora. Santos will construct stock proof fencing around specific work areas such as drilling sumps and pits, to minimise potential impacts on native fauna and livestock. Where possible, consideration of the use of above ground tanks/water storage facilities will be included in the project scope of works to reduce the disturbance footprint and minimise environmental impact. Following completion of drilling activities, remnant fluids will be left in-situ (lined sumps or lined ponds) to evaporate with the ability to transfer to covered above-ground pond as per the NT Well Operations Code of Practice. Where the volume of remnant fluid poses a risk of overflow during the wetter part of the year, fluids may be removed from site or stored (on-site) temporarily in purpose built containers. Chemicals will be stored in appropriately bunded and designated areas for the duration of the drilling operations. No surplus chemicals will be left on site after the well is decommissioned or suspended. In shale hydraulic stimulation treatments, water accounts for more than 90% of the mixture and sand accounts for about 5-9%. Chemicals generally account for less than 1% of the mixture and assist in carrying and dispersing the sand in the low permeability rock. In accordance with regulatory requirements, the chemicals additives are subject to full disclosure. The chemical additives are not specific to the hydraulic fracture stimulation process, having many common household uses such as in swimming pools, toothpaste, baked goods, ice cream, food additives, detergents, cosmetics and soap. An above ground water storage tank provides temporary water storage for use in the hydraulic stimulation process. Source water can either be trucked from a nearby water source or piped along a temporary network. Small dosages of biocide are added to control algal growth particularly under warm and stagnant conditions. Following completion of works, temporary water storage infrastructure is removed from site. The equipment and machinery required to carry out a hydraulic stimulation operation is highly mobile and able to be installed and removed relatively quickly (generally within a couple days). They are designed to comply with state and federal regulations for road transport, and are fitted with safeguards such as an in-vehicle monitoring

	system (IVMS) to ensure compliance of the individual contractors. For any decommissioned well, the well pad and associated camp sites, etc. will be rehabilitated to ensure minimal disturbance. For any suspended well, the wellhead area will be fenced off and well pad site rehabilitated as much as practical to ensure that re-entry for well integrity monitoring and intervention activities can be maintained. Further technical details can be provided on request.
(E) The proposed means of access and access routes for personnel and equipment, both into and within the Permit Area, including particulars of the amount of vehicular and airborne access and any proposals to construct or upgrade roads, landing strips, or other access facilities;	Please refer to Attachment 1 for details of the proposed access routes for personnel and equipment and proposals to construct or upgrade roads. Please note that multiple access options have been included; however, these will not all be required for the final scope. The amount of vehicular access will be variable during the scope of proposed activities, but Santos will aim to design proposed infrastructure that does not adversely impact Traditional Owners, pastoral lessees, nearby industry or the general public. **Initial Access Roads** Planned earthworks are required to provide a safe and practical work area and access to drill exploration wells, water wells, campsites, airstrips and for other operational needs. The access roads for the Northern Locations already exist, but may need upgrading in some sections to meet Santos standards, which are designed to accommodate heavy vehicle usage. Regular watering may occur to reduce dust and additional capping may be added to the surface to reduce maintenance or closure following periods of rain. **Landing Strip** Airstrips and Helipads are commonly used to bring the workforce from a main centre closer to worksites with the aim of reducing fatigue and exposure to land transportation risks. Existing landowner airstrips will be utilised and upgraded under agreement to a condition where charter operator (for crew change), or RFDS or Careflight Air Ambulance (emergency evacuation) aircraft can be accommodated. Helipads may be constructed at each wellsite to provide additional direct access to remote wellsites. **Initial Mobilisation and Final Demobilisation:** Initial mobilisation of drilling rig requires approximately 80-120 loads/trailers mobilised to the nominated Wellsite. A combination of standard trailer loads and oversize loads (for which the required permits for transport will be in place with the NT government) will be used. Demobilisation will involve moving all equipment out from location via the proposed access routes. **During drilling activities:**

	A small number of trailer loads to the wellsite will be required, with some mobilisation of equipment to lay down areas via a combination of trailerised loads (singles, doubles, road trains). A daily commute will occur by 4WD vehicle for crew changes between campsite and rig site. Road maintenance will include the application of imported capping to repair creeks or holes, the addition of water to the road surface to restore compaction or reduce dust generation, and grading to restore drainage by reshaping the road profile or removing rutting. Rollers will be used where necessary to aid compaction. **Fracture stimulation** Initial mobilisation of the frac spread and associated services like coiled tubing and wireline will require approximately 40-60 loads/trailers mobilised to the nominated wellsite. There will also be 50-100 loads to the wellsite required to transport frac materials like proppant to the location. Demobilisation will involve moving all equipment out from location via the proposed access routes. There will be a daily commute by 4WD to mobilise and demobilise crews from the camp to the frac spread and vice versa. **Flow testing:** Minimal personnel, some trailerised equipment haulage to site for initial set up of equipment and then 4WD transport as required for monitoring during flow testing activities. **Well Integrity Monitoring** Scheduled visits for well integrity monitoring one or two personnel as required.
(F) Any fly-camps or other camp sites of less than five days duration proposed to be used;	When and where feasible, temporary local accommodation (i.e. Tanumbirini Station) will be considered to minimise environmental impact. Camps may be constructed within the subject areas. These camps may be capped with suitable clay material if required based on ground conditions. Preference will be given to utilising previously disturbed areas.
(G) Any water, timber or other resources proposed to be obtained from within the Permit Area and surrounding areas;	**Water bores:** Drilling of new water bores and use of existing water monitoring bores are the preferred water supply sources; followed by use of existing station water bores. Water bores have been previously constructed by Santos proximal to the Tanumbirini North and Inacumba North locations, so it may not be necessary to install more. However, further water bores may be installed if needed and will always be located within the subject land. The water taken from water bores is limited by the conditions of the NT Government Water Act provisions and/or appropriate water extraction licence(s) In addition, earthen water holding pond(s) and loadout facilities may be constructed and fenced as required.

	Water will be used for drilling and fracture stimulation purposes and for road maintenance as required. **Construction materials (soils and gravels):** Where in-situ materials are unsuitable, additional fill/clay/rubble for capping of roads, flood-ways, landowner pipeline crossings and leases will be sourced from approved areas; wherever possible this will be done by extending existing quarries or borrow pits. **Borrow/gravel pits:** Borrow pits may be required as a source for extraction of construction materials. The presence of suitable borrow/gravel pits within the subject land approved areas has been confirmed through initial scouting. Management practices include stockpiling cleared vegetation and topsoil in separate piles for respreading over progressively reclaimed areas, and areas to be restored will have battered edges. Maximum excavation depth will be based on the available soil types and volume; however, excavations will not typically extend beyond 3m depth. Where possible, materials stockpiled for construction will be stored within the cleared area and transferred to site as required. Mixing of water with materials to create a cohesive mix may be undertaken at the pit or at the construction site – e.g. lease pad or roadway.
(H) The estimated costs of implementing such activities;	$80m to $100m 2019 budget estimate only. Future activities beyond 2019 will be budgeted separately.
(I) Any proposals concerning employment, training and business opportunities;	To be determined. Santos will provide further details as logistical and program requirements are finalised. Refer to section J below.
(J) If known, the identity of any proposed contractors and sub-contractors engaged or likely to be engaged and the minimum and maximum number of personnel likely to be on the Permit Area from time to time and their roles in undertaking such activities;	**2D seismic acquisition** The contractor is unknown at this point in time as the procurement process is ongoing. At any one time, the seismic crew may consist of approximately 15 personnel, including: ▪ Line preparation (4 personnel); ▪ Surveying (2 personnel); and ▪ Seismic recording (15 personnel). The crew will consist of plant operators, surveyors, line labourers, truck drivers, technical personnel, camp support personnel, paramedics and field management personnel. **Civil Works Wellsite & Access Road Construction** *(Includes Water Bore Construction)* At this point in time the procurement process is ongoing. Santos has been in discussion with several contractors who have good indigenous engagement and local

	experience. It is expected that the following companies will be invited to tender for the 2019/20 scopes of work. • Cairns Industries • Crowhurst / Goodline • Intract • MS Contracting • Rusca Bros • Yindwati At any one time, the civil works crew may consist of approximately 20 personnel, including: ▪ Site management (3 personnel); ▪ Water Bore Drillers (4) ▪ Earthmoving Construction Crew (9) and ▪ Support Crew (4) The crew will consist of plant operators, water bore specialists, truck drivers, camp support, and field management personnel. **Drilling** Primary drilling contractor is proposed to be Ensign Australia Pty Limited for the 2019 program. Future programs could use other, equally qualified, drilling services providers. For other services, Santos will initiate preliminary discussions with contractors to ascertain availability and operational capacity. Further information can be provided once these arrangements are finalised. **Fracture stimulation** The most common contractors for hydraulic fracture stimulation scopes of work are Halliburton, Schlumberger and Condor. We anticipate that one, or a combination, of these companies will undertake the frac works. Each company is highly experienced and qualified for the activities in scope. The workforce associated with this phase of activity will vary from approximately 10 to 40 depending on the specific daily activities undertaken.
(K) The chemical composition of any fluids and solids proposed for use in Hydraulic Fracturing of potential Hydrocarbon producing formations;	Refer to Annexure 4 for a list of chemicals used by Halliburton, Schlumberger and Condor in Fracture Stimulation operations. If chemicals other than those listed are proposed for use, these will be provided to the NLC and disclosed to Traditional Owners at On Country Work Program meetings.
(L) The area, or where appropriate, line distance the subject of such activities (in square or, where appropriate (for example, seismic lines and roads), line kilometres); and	The proposed 2019 work program includes an approximately 10km 2D seismic line around the Tanumbirini North location (see maps below), which is entirely within the previously surveyed area of Authority Certificate C2014/053. The line will not interact with any sacred sites or 'cleared with constraints' areas and will be planned to minimise environmental impact. Any future seismic survey is likely to be of a similar scope, or would require separate cultural heritage and sacred site clearances. Please refer to the below maps and the spatial data provided.

(M) Any other aspect of such activities that is likely to have any Environmental Impact, or in particular, any impact upon Native Title Parties.	Santos has procedures and extensive experience in operating in arid environments. Santos will ensure that any risk of long term impact is minimised and that there is no risk or impact to sacred sites and cultural heritage as a result of the work. To ensure there is no risk or impact to sacred sites and cultural heritage as a result of the proposed work, it is suggested that representative/s of the Traditional Owner group/s accompany the team where possible for any sampling, survey, or construction activities. Santos also welcomes the involvement of local Traditional Owner groups to provide cultural awareness training, welcome to country, and to visit the operations during our activities.

2. Areas of proposed work activities

The proposed work activity falls within previously approved NLC reviewed & AAPA authorised areas approved under AAPA Authority Certificates C2014/053 and C2018/105 that were granted in April 2014 and December 2018 respectively (Figure 2.1.1). This application provides a refreshed work program detailing proposed activities within the approved areas and ensuring that no activity will occur within the identified restricted work areas (RWAs). Pending authority, council and state approvals Santos would propose to commence seismic & civil activities as early as Q2 2019. Access track preparation, well pad construction and associated works will be undertaken in preparation for seismic and drilling operations. Where possible existing access tracks will be upgraded; however, new access tracks will be created (within the surveyed areas only) if it achieves the objective to minimise the overall impact of the operations. Temporary camps will be used to support these activities and will remain with the current cultural heritage authorised areas.

2.1 Inacumba North Lease Pad and Access

Civils work at Inacumba North is proposed to facilitate access and prepare the area for the exploration of the Inacumba well. The approximate coordinates of the proposed location are presented in Table 2.1.1. GIS files are attached to this application that complement the scope of work described Table 1. Figure 2.1.1 is a location map showing the Inacumba North Area.

Projection	GDA94 Zone 53, CM 135°
Latitude	16˚ 30’ 58.92” S
Longitude	134˚ 50’ 33.11” E
Easting	483196
Northing	8173939

Table 2.1.1: Approximate wellhead coordinates of proposed 2019 Inacumba North well.

2.2 Tanumbirini North Wellsite Infrastructure & Access

Civils work at Tanumbirini North is proposed to access and prepare the area for the exploration and appraisal of the Tanumbirini wells. Tanumbirini-1 well coordinates and the approximate coordinates of the proposed Tanumbirini-2H location are presented in Table 2.2.1. GIS files are attached to this application that complement the work-scope briefly described in Table 2.2.2. Images have been provided in figures 2.2.1 to 2.2.4 as a guide of the approximate location of each zone proposed in the lease pad area and access to the lease.

Location	Projection	GDA94 Zone 53, CM 135°
Tanumbirini-1 (drilled in 2014)	Latitude	16° 23' 56.59" S
	Longitude	134˚ 42’ 13.76” E
	Easting	468375
	Northing	8186900
Proposed Tanumbirini-2H well (2019 program)	Latitude	16° 23’ 58.01”S
	Longitude	134° 42’ 12.71”E
	Easting	468344
	Northing	8186856

Table 2.2.1: Approximate wellhead coordinates of proposed 2019 Tanumbirini North well

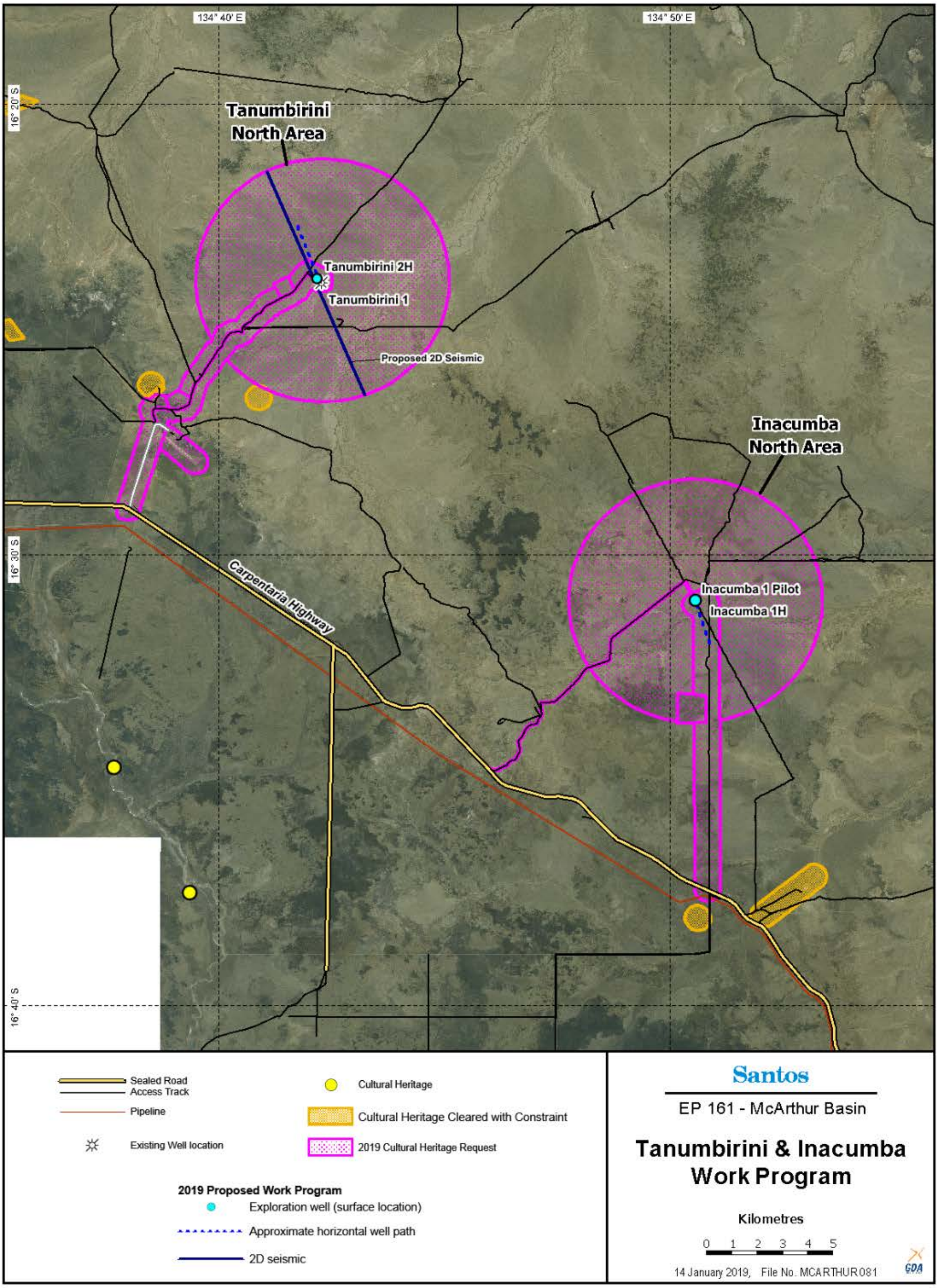


Figure 2.1.1: Overview of the Northern Area showing the Inacumba North Area and Tanumbirini North Area.

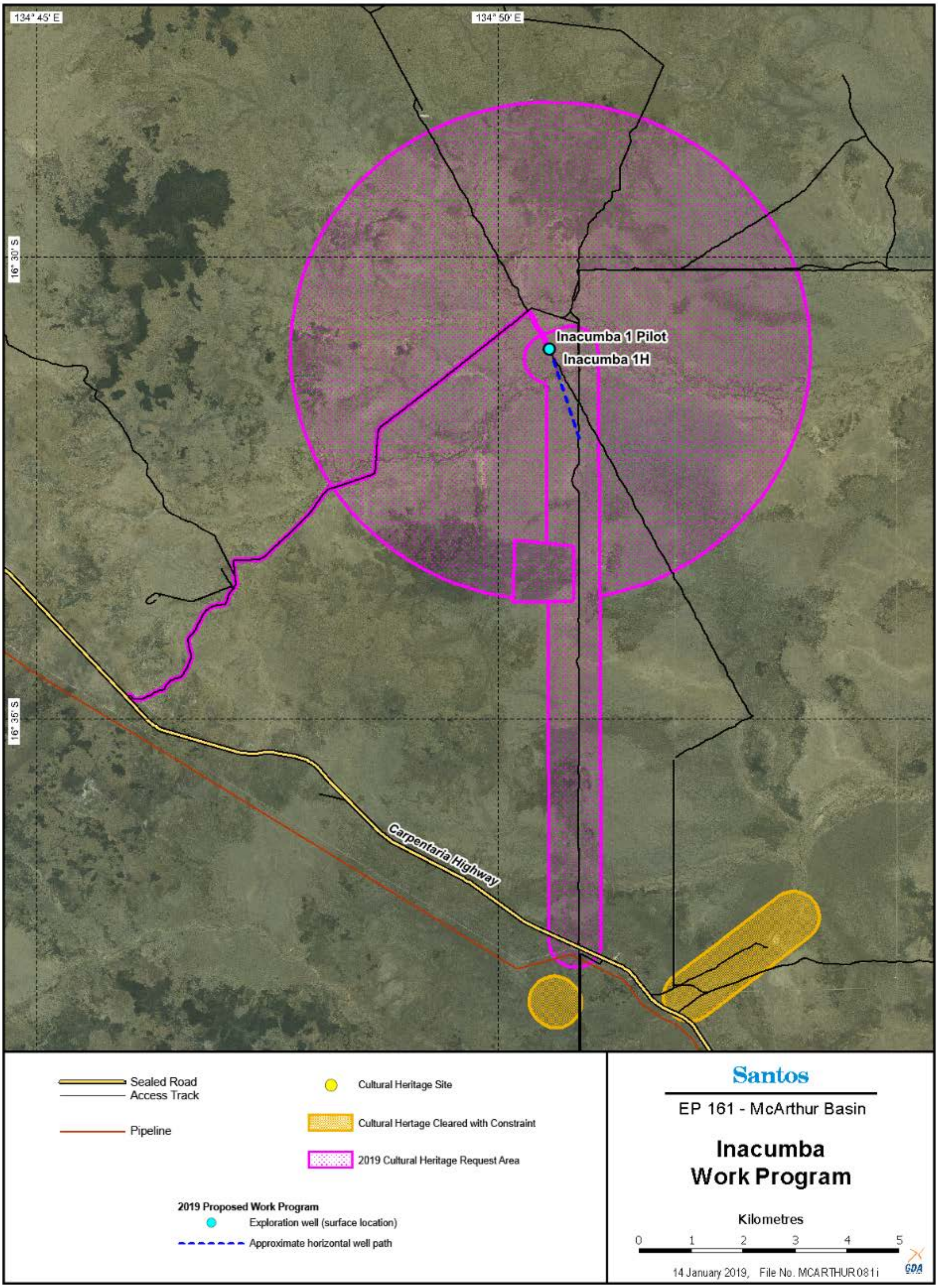


Figure 2.1.2: Map showing the Inacumba North Area

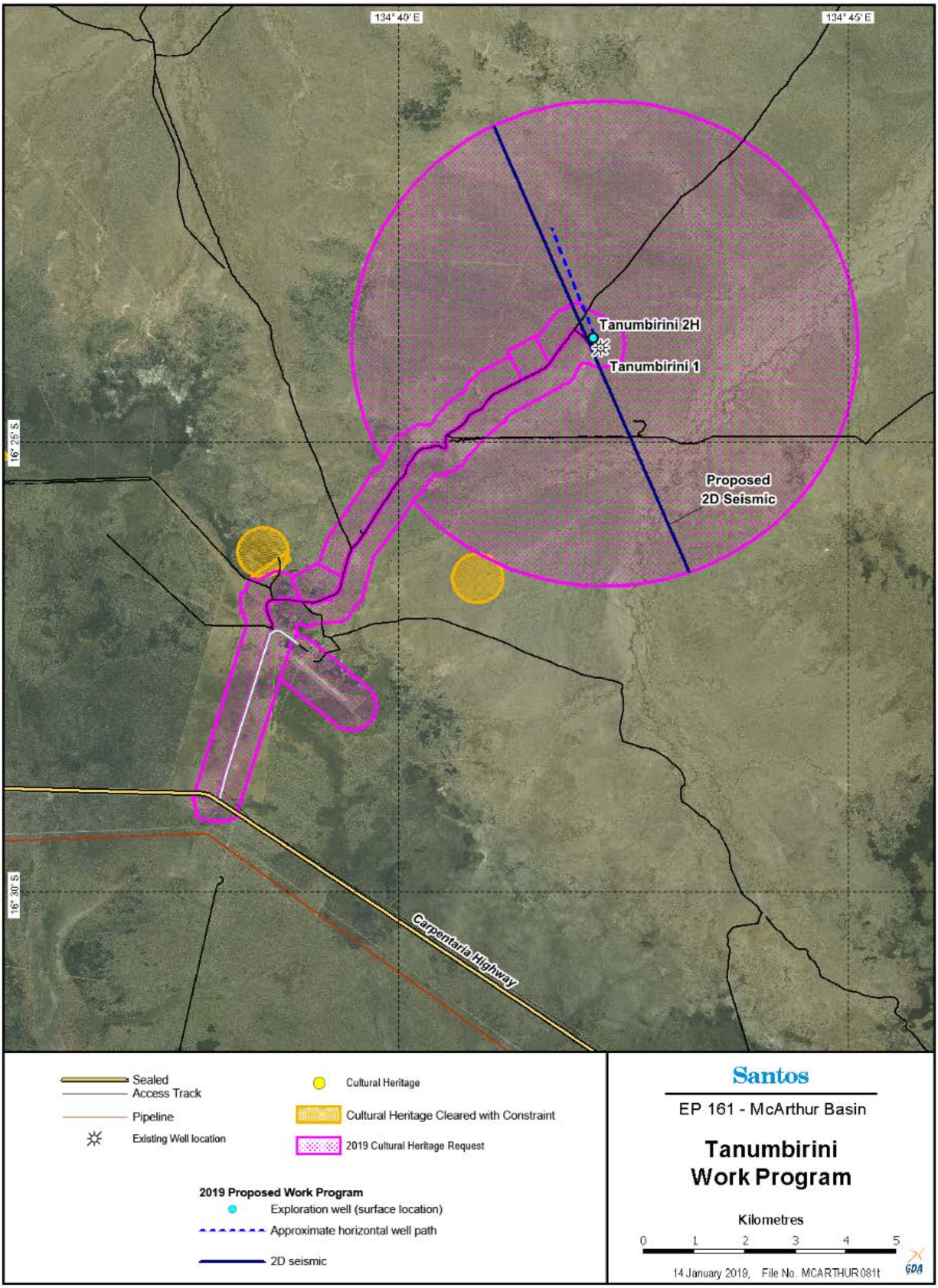


Figure 2.2.1: Tanumbirini North Area

<u>Attachment 2 – ANNEXURES</u>

Annexure 1 – Description of 2D Seismic Operations

The seismic method

Seismic acquisition allows the explorer to 'image' below the surface and identifies areas where oil and gas may have accumulated. The seismic method uses energy sources such as vibrator trucks (or equivalent) to generate sound waves that travel into the earth and are then reflected from subsurface geological structures. The returning reflections are recorded in a digital format and sent to a seismic data processing centre to produce a 'cross-section' of the layers of the earth's crust. The following sections explain the field procedures for recording seismic data.

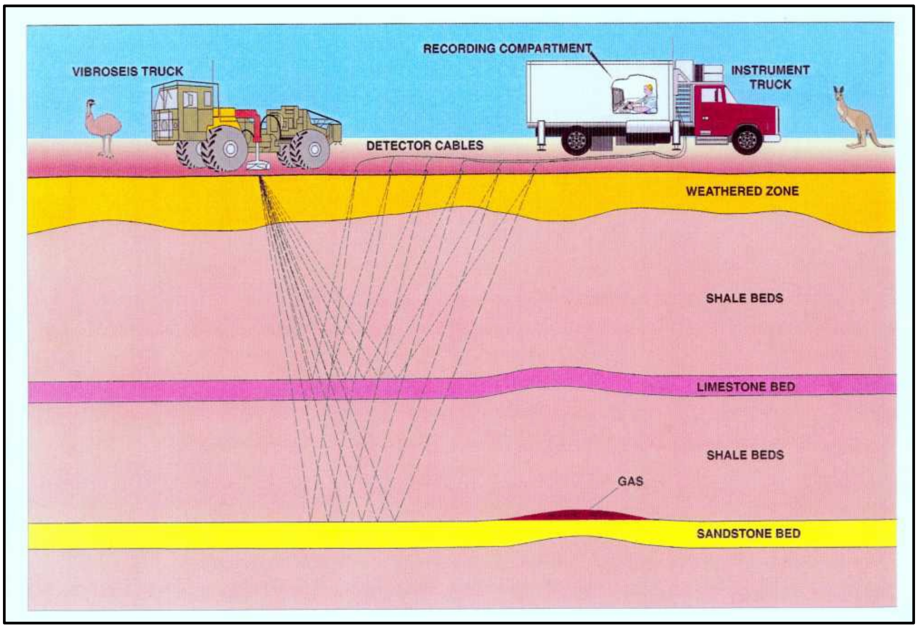


Figure: Schematic of typical seismic acquisition operation

Planning

Once the exploration team have proposed a seismic program, the line layout is plotted onto detailed topographic maps and aerial images to begin planning the survey.

Seismic surveys can be of a regional nature covering a very large area including the first look at an area or an infill type survey that is infilling other seismic surveys. Typically infill surveys are a tighter density of lines covering a smaller area than a regional survey.

Regardless of their regional or infill nature, a seismic survey can be as small as a single line or up to dozens of lines totalling hundreds of linear kilometres. In the case of an infill type survey, the lines will usually be set out in a rough grid with line spacing ranging between 0.5 – 5km.

2D Seismic lines are used to layout the seismic detectors that pick up the reflected sound waves and are also travelled by the vibrator trucks that provide the sound waves recorded on the seismic detectors.

Seismic lines are usually prepared tracks that are 4-5 m wide. The energy source for conventional 2D seismic lines typically moves along the line as recording progresses. The seismic lines are carefully laid out to avoid sensitive environmental sites as well as cultural features such as buildings, dams, water wells and known cultural heritage sites. The key aspect of field acquisition is to get equipment (usually vehicular based) and personnel along the planned seismic lines and acquire sufficient data to adequately 'image' the subsurface.

The safety of field personnel is a key aspect of any seismic operation. This involves compromise between what is logistically, environmentally and economically possible.

Cultural heritage clearance

A cultural heritage clearance is usually the first field activity to occur on a 2D seismic survey. Clearance logistics vary from project to project. The appropriate method for the project is decided during early discussions between representatives of the explorer and the Native Title Claimants/Traditional Owners.

Depending on the method used, Santos may employ a field liaison officer who will be the link between the field clearance operation and Santos. He/she will work closely with Traditional Owners and will provide survey support to the group if required.

In the case of the McArthur, all requests for Cultural Heritage Clearance are directed to the Northern Land Council who will then in turn consult with Traditional Owners and their own technical specialists to facilitate approval to proceed with the survey. Typically this approval will come with a number of conditions that must be abided by for the survey to proceed.

No work will commence on the ground by Santos or any of its contractors until this approval (whatever its form) is obtained.

Seismic Line and Access track preparation

Once the line positions for a project have been cleared by the cultural heritage group(s), the line preparation crew can commence work.

The line preparation crew usually operates simultaneously on different lines using D6 bulldozers (or equivalent) for the initial pass and then a grader may be utilised for tidy up work if required. Daily production of prepared line varies greatly and is primarily dependent on the terrain. It may vary from 5-20km per day per machine. In areas of low or sparse vegetation, the bulldozer will be utilised to simply walk with the blade up in easily traversable terrain, with the marks of the tracks being sufficient for the grader (if required) and the surveyors to follow. Where required for safety reasons, the blade may be used for minor clearing of topsoil or sand dune access. Blade work is kept to a minimum and generally restricted to skimming the top off rough ground to provide safe access for subsequent operations.

The grader that follows the dozer simply tidies up the resultant line. If any windrows are left behind the grader will knock them down to prevent any channelling of rain water and thereby prevent future erosion. In many areas, the dozer will simply walk and there will be no work required by the grader.

All machine operators are given detailed project inductions at the start of each survey with project specific issues discussed in great detail such as Cultural Heritage, Environmental, Safety and infrastructure requirements.

The line positions are pre-programmed into GPS units mounted in the dozers. These GPS units allow the dozer operators to get real time position updates. These are plotted on a display that also indicates the Cultural Heritage cleared corridor for the dozer operators.

The dozers weave around vegetation stands and on open ground the machines weave every 75-100m to reduce the visual impact. Other items such as roads, infrastructure, detours plus any exclusion zones or restricted work areas are also displayed on the dozer GPS units so the operator has a detailed project map shown in relation to their position at all times.

Figure: Example seismic line (Mereenie) after line Preparation

The line preparation personnel typically operate out of a small mobile self-contained camp that moves with operations regularly. The project surveyors are also normally accommodated in the same camp along with a paramedic and Santos supervisor.

The line preparation phase may last anywhere from a couple of days to a couple of months dependent on the size of the survey.

Seismic Line Surveying
Surveying commences within a day or two of the commencement of line preparation.

A survey team is typically made up of a Senior Surveyor and a number of GPS operators. The senior surveyor is typically responsible for all office work plus doubles as the dozer pointer to assist the dozer operators if they are working in a highly constrained area. The GPS operators are responsible for surveying each seismic line and placing the required survey markers.

The GPS operators use real time kinematic GPS receivers to position receiver/source points. Surveyors generally insert numbered wooden pegs and plastic tipped “pin flags” to indicate the points; however, a seismic line can be “stakeless” in special circumstances such as when working on properties with a certified organic status. Markers protrude about 30cm above ground level and may be placed as deep as 100mm in soft sandy terrain. All of these markers are removed on completion of the recording phase. Line detours are often marked with biodegradable flagging, which is also removed. Each survey team (one surveyor in a light 4WD vehicle) generally makes only one pass over any given section of line.

Figure: Light 4WD vehicles used to pass along proposed seismic lines.

Back packing of the survey effort occurs in areas where line preparation and vehicle access routes have deviated from the true line position and markers have to be inserted on foot. This could be due to a variety of reasons, the more common being Cultural Heritage restrictions, environmental restrictions or infrastructure concerns. In these situations, the following recording crew will position cables and geophones by foot and no vehicles would traverse the area.

Figure: Surveyor pegging on newly prepared seismic line

Surveying operations are normally run in conjunction with the line preparation operation and therefore have about the same duration.

Seismic Data Recording

Approximately 1-2 weeks after the line preparation and surveying are completed in an area, the recording operation will commence. This operation is the largest part of the seismic operation in terms of personnel and vehicles. Depending on the size of the program, a 2D recording crew would normally number up to 35 personnel and up to 15 light vehicles. It should be noted that the bulk of the on ground equipment is transported to site in heavy vehicles. These heavy vehicles will only be used on existing tracks/roads and will not travel along the seismic lines.

Work commences with the deployment of small seismic detectors (geophones) that contain the geophone element, a GPS receiver, hard disk storage and a battery. These are deployed along the line at a pre-determined interval, dependent on geophysical target, which can be between 2.5m and 25m increments.

Figure: Seismic line crew deploying geophones

Recording would normally commence when a sufficient number of geophones have been deployed. This layout is termed "the spread" and it picks up the acoustic energy transmitted from subsurface layers during the seismic surveying process, converts it to electrical energy and stores that information on a hard drive within the unit. Surveys may have up to 12km or more of spread live at any one time.

Recording consists of the vibrator trucks travelling along the line and stopping at regular increments, generally between every 10m and 20m, to "shake" the ground. After shaking in one spot for around 12-15 seconds, the trucks will move onto the next point along the line and shake again. During this, the trucks are centrally located in the line spread, resulting in around 6km of spread behind the trucks and 6km in front of the trucks. The seismic labourers (or "juggies") rotate the redundant spread from behind the vibrator trucks to in front of the vibrator trucks continuously throughout the day to ensure the vibrators can continue without delay.

Figure: Seismic line crew planting geophones

Figure: Geophone planted in the ground

Once the vibrators are finished on a line, the final spread behind the vibrators is picked up and the line is complete.

Figure: Seismic Recording Truck

All operational vehicles stay on the prepared line with the exception of parked vehicles that have to park off line to avoid causing noise on the spread and interference with line traffic. While parked off the prepared line, vehicles remain within the corridor cleared by the cultural heritage teams.

Along any single line the following vehicle passes can be expected to occur during normal operations.

Bulldozer: 1 pass
Grader: 1 or 2 passes
Light vehicles: Multiple passes during surveying and recording operations.

Seismic Line/Access Track and Campsite Restoration

Once a seismic line is completed, restoration work may commence if required. The majority of seismic lines and access tracks do not require restoration work, as one of the main objectives is to prepare and utilise them in a way that will facilitate rapid natural recovery. However, instances that can give rise to restoration are:

- It is a requirement of the project Environment Plan for all lines to be restored
- Wheel ruts have been created after wet periods or bulldust
- Windrows have not been fully removed by the grader
- Windrows need to be removed at intersection of lines and public tracks
- Public access tracks need to be reshouldered where necessary
- Access tracks have sustained damage due to extensive seismic traffic.

Normally a single grader is all that is required to carry out the restoration work. Methods used for rehabilitation include;

- Ripping of compacted areas with rear tynes
- Windrow material and vegetation pushed onto the line
- Public road windrows reinstated.
- Wheel rut material used to infill affected areas.
- Affected water course channels and creek banks reinstated to pre-survey profile.

Environmental Monitoring

During the above activities the maintenance of environmental standards are monitored closely by the Santos field representatives and Contractor section heads. All crew personnel are environmentally inducted prior to start up. Environmental monitoring points (EMP's) are set up close to easy vehicle access and the natural rehabilitation is monitored photographically over a period of years until rehabilitation is complete.

Annexure 2 – Description of wellsite civils works and access

Various earthworks are required to provide a safe and practical work area and access to drill gas wells, water wells, campsites, airstrips and other operational needs. The construction designs will be determined by a framework that supports users, landowner and regulatory needs.

All civil work activities will be fit for purpose and will be undertaken to minimise impacts on Traditional Owners, pastoral lessees, nearby industry or the general public. Design and construction will be appropriate for:

a. The types of vehicles that need to use the road.
b. The type of road planned and the surface material – e.g. high clay (Black Soil), dunefields or fine bulldust soils require differing construction and maintenance requirements.
c. Expected weather conditions – i.e. all weather access and mobility can be improved by formation design, adequate drainage, plus capping with rock, rubble, or "Durabase Matting".
d. The conditions of the approved Environmental management plan, which requires a civil solution to manage erosion, wildlife impact, bushfire, and flood risks.

Optimally designed, planning and execution of civil works are critical to ensure that:

1. **Wellsites** are constructed to create safe, fit for purpose work areas that include several distinct zones:
   i. Drill hardstand is level and compacted using selected fill that supports the loads and pressures of drilling rig equipment operations.
   ii. Drill pad work area is level and surrounds the drill hardstand – this area needs to be compacted and support ancillary equipment like generators, fluid treatment systems, piperacks and forklifts.
   iii. Wellsite work areas that surround the drill hardstand and cuttings pits have a level tolerance of <2% and must be compacted to support the movement of trucks and forklifts and bunded areas created for the storage of chemicals, racks and shelving supporting casings and other consumables.
   iv. Cuttings pits should be located in an area accessible directly from the fluid treatment systems (Mud Tanks) or loaders (in the case of "sumpless drilling"), usually on multi well pad sites. Pits can be unlined, lined with a bentonite and clay mix to create an impermeable layer, or lined with a synthetic membrane to retain drilling fluids during drilling and subsequent dehydration process prior to backfill.
   v. Flarepits should be located in a position down-wind from the prevailing wind direction and ideally >35m from hole centre or any other sensitive zones.
   vi. Mini camps, crib/first aid rooms and site management offices, are located outside the wellsite work/hardstand areas; offices will have a clear view of the rig floor. This area will be level, compacted and accessible to supplies and emergency vehicles, and usually include emergency muster points and vehicle parking.

2. **Access Roads** are designed and constructed so that road trains can deliver equipment and supplies to the sites, and personnel can be safely moved around or delivered to site. Roads may be watered to reduce dust, and/or capped to reduce maintenance and/or closed following rain.
3. **Laydown yards** are constructed so that materials can be offloaded and stored for use as and when required. Materials include, casings, tools and mud chemicals. Laydown yards must provide enough room for the safe movement of trucks and forklifts.
4. **Campsites** for workers' accommodation, and refuge during severe weather, illness or injury, are located in positions that provide isolation from fire and flood dangers. Campsites must be reliably resupplied and provide workers with good comfort and recreation facilities. The location of campsites should reduce travel and fatigue exposure to acceptable levels.
5. **Water Bores** for the supply of water to aid compaction and reduce dust; support drilling, completion and hydraulic fracture stimulation operations; and supply water to the campsite for amenity needs. It is preferable to have a low salinity water supply close to site. However, saline aquifers are suitable for some operations, reducing road maintenance costs and the quantity of imported potable water.
6. **Water Storage Pads**, are required so that water tanks can be erected, providing sufficient volume and delivery of water at a rate required to support the works. Typically larger storage is required where water bore flow to surface is low.
7. **Airstrips and Helipads** are used to transport the workforce from a main centre to the worksite. Air transport reduces fatigue and exposure to land transportation risks. Existing landowner airstrips will be utilised and upgraded under agreement to a condition where charter operators (for crew change),

or RFDS or Careflight Air Ambulance (emergency evacuation) aircraft can be used. Helipads may be constructed at each wellsite to provide additional direct access to remote wellsites.

Annexure 3 – Description of drilling, evaluation, fracture stimulation, completion and flow testing activities

3.1 Drilling

Oil and gas wells are typically drilled by rotating a drill bit on the end of drill pipe while exerting downward force on the drill pipe. During drilling, fluid is pumped through the inside of the drill pipe or “string” to the drill bit and back up the outside of the drill string to lift drill cuttings out of the hole. The drilling fluid / drill cuttings are then channelled into tanks or bentonite and local clay lined pits and the drill cuttings are separated from the drilling fluid; drilling fluid is then recycled down hole in a continuous process. The well is drilled deeper by adding a length of drill pipe to the drill string; this is repeated until the well, or a section of well, reaches the target depth. Once the target depth is reached, casing composed of concentric steel pipe is installed into the well and cemented in place to provide the structural integrity and well integrity barriers for the designed life of the well.

The figure below illustrates a typical drilling rig layout and lease and access roads required for a Cooper Basin drilling operation. The drilling rig along with specialised wellsite support services and camp are mobilised to the well location, comprising 100-150 truckloads. The drilling rig camp is either located adjacent to the wellsite or in a location central to multiple wellsites. It is designed to accommodate the crew working at the wellsite, and will expand and contract as required to meet personnel requirements.

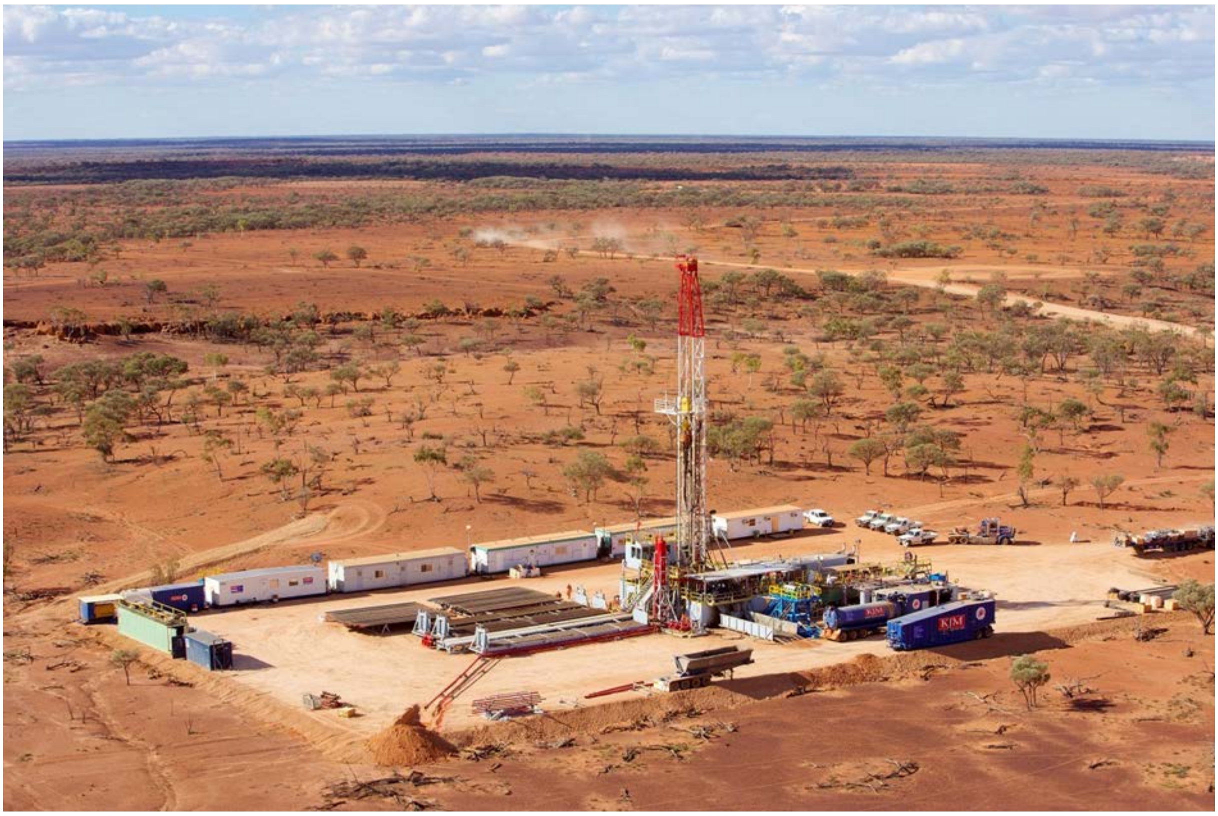


Figure: Drilling rig in the Cooper Basin. (Source: Santos 2016)

Wells are drilled to reach the gas formation targets through a series of hole sections. While drilling, mud logging samples are captured in order to characterise the formations that are being drilled through and to calibrate the geological model. It is expected that 2-3 ML of water will be required to drill each well, with the water being supplied from water bores installed at or near the drill location. Each hole section serves a specific purpose for well construction and well integrity as outlined below:

1. The Conductor Hole Section is drilled and cased to stabilise the surface sediments from the drilling of subsequent drilling phases (i.e. it prevents loose soils from caving into the borehole), and is cemented into place to ensure an appropriately robust seal (up to ground level). The conductor casing also serves to isolate aquifers near surface, if present.

2. The Surface Hole Section is drilled and cased to isolate shallow aquifer systems and to stabilise the well for subsequent hole sections. The hole section will be drilled with drilling fluid that exerts a higher hydrostatic pressure on the rock face than is present naturally in the rock pore space, ensuring formation fluids do not enter the wellbore. Other techniques such as underbalanced or managed pressure drilling may be applied dependant on the downhole environment. The surface casing is cemented in place from bottom to top to ensure effective pressure isolation of shallow aquifers from deeper hydrocarbon bearing zones encountered in subsequent hole sections. Finally, the casing is pressure tested to simulate well life design specifications.

3. After the surface casing is installed, a Blowout Preventer (BOP) is installed onto the well at surface to provide a second barrier along with the drilling fluid. At the commencement of drilling the next hole section (i.e. only 2-3m of new hole drilled), a Leak Off Test (LOT) or Formation Integrity Test (FIT) is conducted to determine the rock strength. This will ensure the well is drilled without risk of the rock failing due to exerted pressure and will ensure the fluid used for drilling the well has the appropriate kick tolerance.

4. The Intermediate Hole Section(s) may be drilled and cased to isolate deeper aquifer systems (if present), to contain pressure that may occur during the subsequent hole section, or to isolate a geohazard, like a salt formation prior to drilling deeper. The hole section is drilled with drilling fluid that exerts a higher hydrostatic pressure on the rock face than is present naturally in the rock pore space, ensuring formation fluids do not enter the wellbore. Other techniques such as underbalanced or managed pressure drilling may be applied dependant on the downhole environment. As with the surface casing, the intermediate casing is cemented in place to ensure appropriate well integrity. Finally, it is pressure tested to simulate well life design specifications.

5. The Production Hole Section is drilled to intersect formation targets containing oil and/or gas and is drilled to a depth below the lowest hydrocarbon bearing target. The hole section is typically drilled with drilling fluid that exerts a higher hydrostatic pressure on the rock face than is present naturally in the rock pore space, ensuring formation fluids do not enter the wellbore. Other techniques such as underbalanced or managed pressure drilling may be applied dependant on the downhole environment. Logging while Drilling (LWD) can be used to gather data in real time to gain an understanding of the petrophysical environment.

6. If well trajectory allows, openhole wireline logging is generally performed after the production hole section has been drilled and prior to the production casing being run. Wireline operations for Santos are undertaken by a number of different industry recognised specialist service companies. Different energy sources are lowered into the well via wireline including density, neutron, acoustic and electrical logging tools. Calculations based on the received signals are undertaken to evaluate the different parameters of the formation such as porosity, permeability, rock type and hydrocarbon saturation. This information is used to ascertain whether the well is economical to run production casing for future production. If the well is not currently economic, a decision not to run production casing may be made requiring the well to be plugged and decommissioned or plugged and suspend for future operation.

7. The wireline logging evaluation program may include a vertical seismic profile (VSP) or checkshot survey, or a 'walk-away' VSP. These geophysical techniques are similar to surface seismic exploration, except the detectors (geophones) are located in the well bore, rather than at the surface, and the surface source is stationed at specific locations around the well. The geophone array comprises one to several geophones on wireline. The surface seismic energy source is either an airgun (in a water filled drum and pit) or a small vibrator truck located as close as is safe and practical to the well bore. The geophone array is run to the bottom of the hole on the wireline, and is then moved up the hole at regular intervals (e.g. 15m) and the stationary surface source is triggered. The geophones record the time it takes for the seismic energy from the surface source to arrive downhole at the geophone. The data recorded provides accurate velocity information and is processed to produce a seismic wavelet well-tie, such that the well can be "tied" to the 2D seismic line on which it is located.

8. After the production hole is drilled and logged, production casing is installed to the total depth of the wellbore and cemented in place. It is pressure tested to simulate well life design specifications. The purpose of the production casing is to provide isolation between the hydrocarbon reservoirs and all other overlying formations, to contain the pressurised fluid used to hydraulically stimulate the target zones, and to provide effective wellbore integrity for well production. High quality steel casing is designed specifically for each well. If the well does not require hydraulic stimulation, a lower grade of steel casing may be used that meets the design requirements for the life of the well.

Casing design scenarios are modelled using well-established and reviewed techniques to simulate the design loads for collapse, burst and tensile failures that could conceivably be observed during the operational and production phases. The results of these analyses direct the selection of casing grade and weight. All casing is tested by Santos and the contractor using specific Quality Assessment and Quality Control (QA / QC) procedures prior to installation to ensure compliance with the Santos engineering and regulatory specifications.

After each hole section is drilled, the steel casing is cemented in place. The correct composition, volume and placement of cement is critical for well integrity. The cement serves two purposes – it provides protection and structural support to the casing while also providing zonal isolation between different formations, including groundwater and aquifers. The cement and required additives are high quality materials produced specifically for oil and gas operations with the materials selected designed to address the specific conditions of a particular well.

Santos and the cementing contractor ensure the cementing material and equipment is adequate to achieve the well design objectives and ensure effective isolation. Prior to pumping the cement, it will be laboratory tested against the engineering design and actual downhole conditions such as temperature. The cement is tested using specific QA / QC procedures and includes the following:

1. slurry density
2. thickening time
3. fluid loss control
4. free fluid
5. compressive strength development
6. fluid compatibility (cement, mix fluid, mud)
7. sedimentation control
8. expansion or shrinkage characteristics of the set cement
9. static gel strength development
10. mechanical properties (e.g. Young’s Modulus, Poisson’s Ratio, elastic / compressibility characteristics)

Cased hole logs can be run inside the cemented casing to validate the quality and integrity of the cement sheath bond to the casing and to the formation. Typically, these logs include:

1. gamma ray - measures naturally occurring gamma radiation to characterise the rock or sediment in a borehole
2. casing collar locator - a magnetic device that detects the casing collars
3. cement bond log - an acoustic device used to measure the properties of the cement sheath and the quality of the cement bond between the casing and the formation

The cement bond log is an acoustic device that can detect cemented or non-cemented casing. It works by transmitting a sound or vibration signal into the casing, and then recording the amplitude of the arrival signal. Casing that has no or poor quality cement surrounding it (i.e. free pipe) will have large amplitude acoustic signal because the energy remains in the pipe and isn’t transmitted to the formation. Casing that has a good cement sheath (fills the annular space between the casing and the formation and effectively couples the two) will have a much smaller acoustic amplitude signal as the energy is absorbed by the formation due to effective acoustic coupling. Santos uses experienced contractors to identify the key features of the cement quality to ensure the integrity of the cement seal for each casing pipe sheath.

3.2 DFIT

A Diagnostic Fracture Injection Test (DFIT) goes by many names: mini-frac, mini fall-off, datafrac, etc.; but all refer to the act of injecting small volumes of a clear fluid (usually with a small percentage of Potassium Chloride e.g. 2 to 3% KCl) at low pumping rates to create a fracture before the wellhead is shut-in and the pressure allowed to fall-off naturally. The fluid contains no proppant so that the fracture can relax and close naturally when pressure is released. The pressure changes are measured with high-accuracy gauges that are either placed deep in the wellbore or at surface on the wellhead. The analyses of fracturing pressure, during injection and after shut-in, provide powerful tools for understanding and improving the fracturing process. The importance of this DFIT analysis of fracture pressure was recognized in 1958 by Godbey, J.K. and Hodges, H.D. and pioneered by Nolte in 1979 who introduced the G-Function based on material balance and the Carter leak-off model. Barre et al. in 1996 recommended using the G-Function and its diagnostic derivatives to identify fracture closure and signatures of non-ideal leak-off behaviours such as tip extension, pressure dependant leak-off (PDL) and storage height recession signatures. These signatures help operators recognise fracture behaviours and design fracture stimulation programs accordingly to ensure that the targeted reservoirs are stimulated optimally. Below are examples of the signature behaviours that are commonly used in the industry to observe fracture injectivity responses:

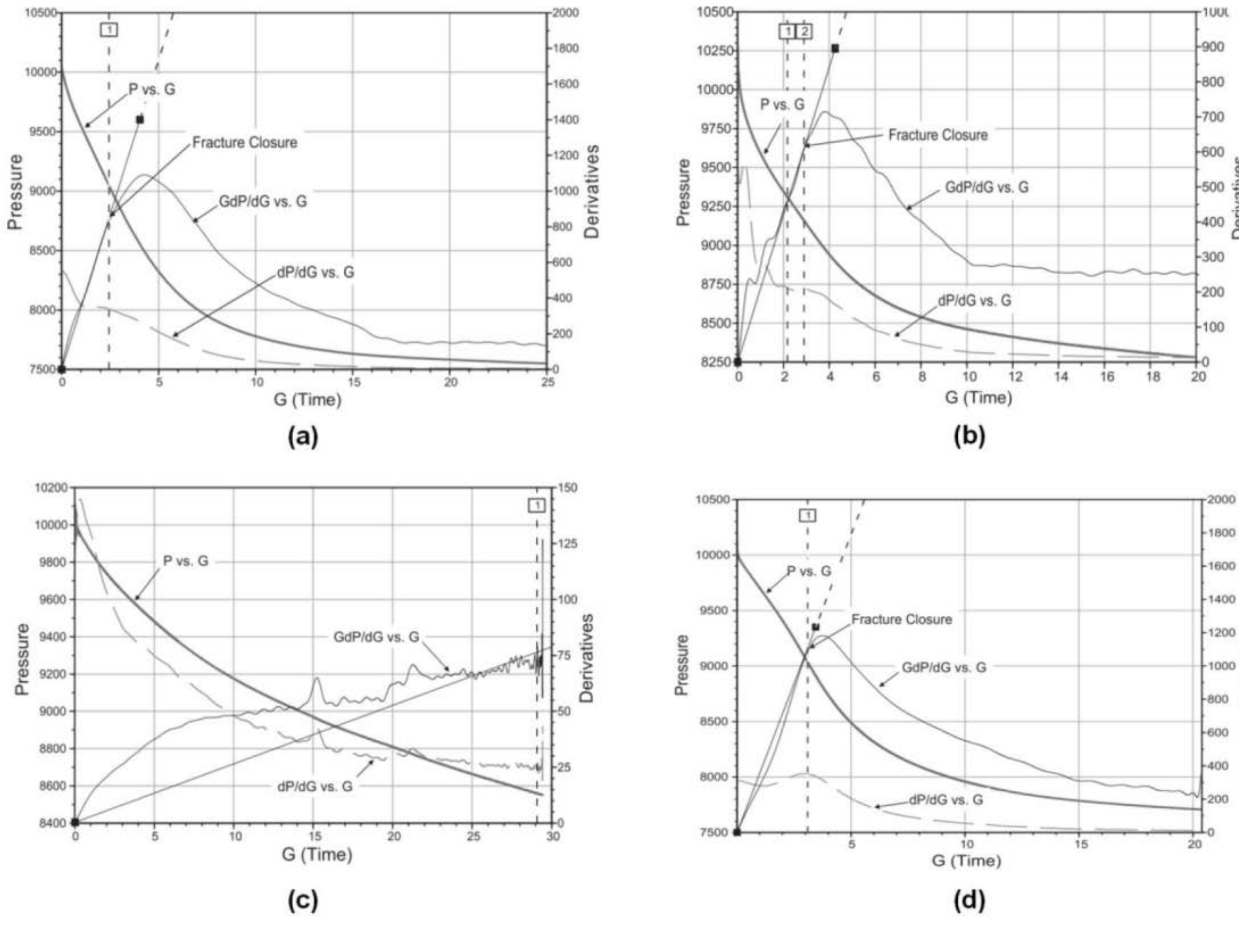


Figure: (a) Normal leak-off; (b) pressure dependant leak-off (PDL); (c) tip extension; (d) storage/height recession signatures on G-function plots (Barree et al. 2009).

Models have also been built to predict the fall-off pressure of an ideal normal leak-off DFIT using standard pressure transient analysis (PTA) log-log diagnostic plots. The figure below presents a log-log diagnostic plot of the basic fall-off response shape of a normal leak-off, which is interpreted as a 3/2 slope on the Bourdet-derivative (with respect to superposition time).

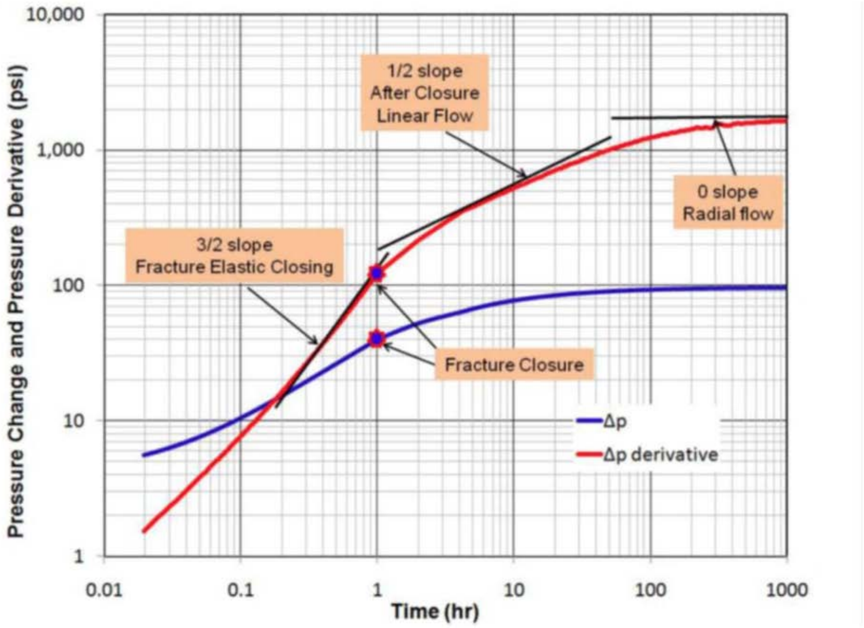


Figure: Log-log diagnostic plot of an idealised fracture-injection/fall-off test (Marongiu-Porcu et al. 2011).

3.3 Fracture Stimulation Evaluation

Pressure Monitoring

During a fracture stimulation treatment, computer assisted live monitoring allows for potential problems (surface or down-hole) to be identified and corrected quickly. An example of live monitoring applied to downhole conditions is if pressure communication between the annulus of the well and inside of the well is identified. Where communication is identified, it may be an indication that the first barrier control (as part of the well's integrity management) has been compromised and the treatment will be stopped immediately.

The figure below depicts information presented during real time stimulation operation monitoring. Key parameters such as surface, bottom-hole and annular treatment pressures, proppant concentrations, volume of injected fluid and fluid additives are monitored. The modelled pressures are compared with the actual pressures and can provide useful information in evaluating the overall fracture growth and fracture geometry achieved. This calibration process is used to refine and improve subsequent designs as part of the design optimisation process.

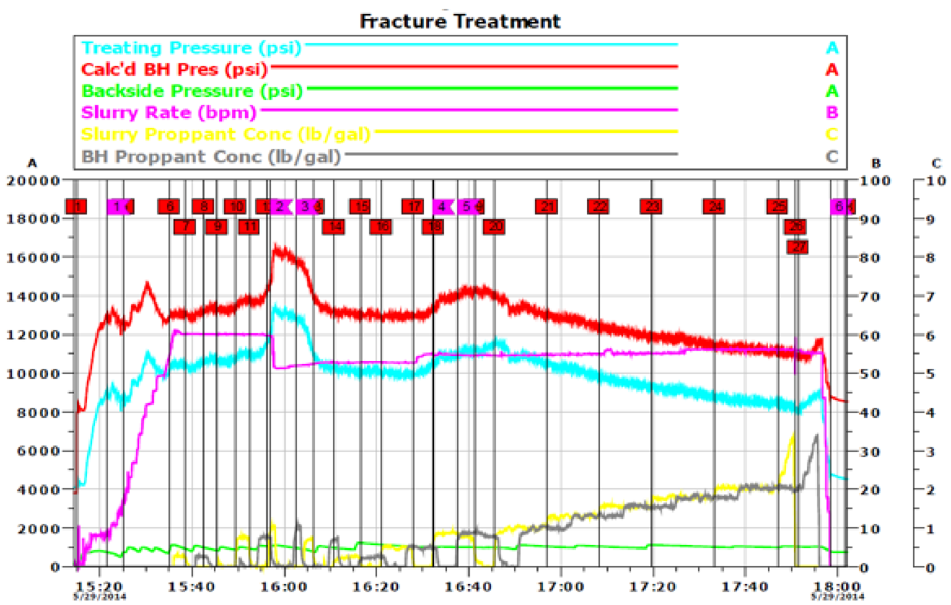


Figure: Real time monitoring of hydraulic fracture parameters (pressure, rate etc.) on a shale gas frac in the Cooper Basin (Santos 2014)

Tracers

Chemical tracers are used to determine the relative contribution from each fracture stimulation stage. The low dosage chemical are designed to be unique in composition and able to be absorbed into the water or gas phase. This enables the operator to determine the performance of each frac stage and incorporate optimisation learnings into future campaigns.

Microseismic

Advanced stimulation monitoring techniques such as microseismic monitoring, may be used to evaluate fracture azimuth, fracture height and fracture half length. This information can be further used to calibrate the hydraulic stimulation model predictions. Microseismic monitoring involves the use of sensitive receivers (“geophones”) at the surface or within one or more nearby wells to detect and locate in 3D space the releases of energy associated with the propagation of the stimulated fractures. The figure below shows an example of a side-view of the locatable microseismic events that were detected during the multi-stage hydraulic stimulation of a Cooper Basin horizontal shale well, with the positions of the events colour-coded by stimulation stage. The modelling and field results show good agreement.

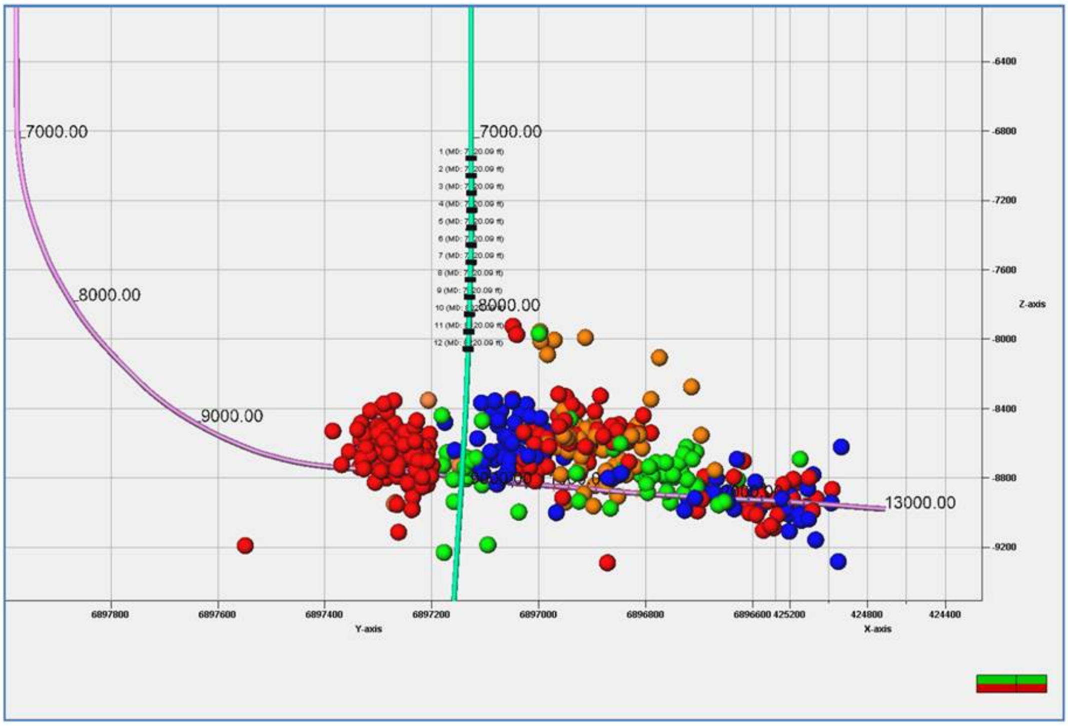


Figure: Microseismic events mapped during the 10 stage shale hydraulic fracture treatments pumped in the Cooper Basin. The different colours represent the different frac stages (Santos 2014).

The microseismic results are supported by detailed studies such as by Fisher and Warpinski (2012) which have reviewed height growth data from unconventional (shale) plays in the US including the Barnett, Marcellus and Woodford shales. These studies have indicated that maximum height growth is typically far less than 300m when contained within a relatively homogeneous layer.

Tiltmeter installation

Tiltmeters are very sensitive surface tools for measuring very minor displacement or movement in the subsurface. They are used in hydraulic fracture stimulation operations to provide insight into the spatial extent and orientation of induced fractures.

Tiltmeters are typically installed into pre-drilled and cased holes drilled with an 8” or 10” diameter bit to a depth of around 12 metres.

Once the drilling is completed a 4” PVC pipe is then cemented in place within the hole. The cement secures the 4” PVC pipe to the ground around it to ensure good coupling for the tiltmeter. The cement ends around

1.2m below ground. To further minimize unwanted noise a larger 8 – 10" pipe around 1.8m in length is then placed around the smaller pipe to a depth of about 1.2m below the surface. The tiltmeter tools are then lowered into the inner 4" string of PVC. A small amount of sand is poured around the tools to give positive coupling to the surrounding ground. An end cap is then placed over the 8" PVC pipe to make the entire setup weatherproof.

Drilling of the tiltmeter holes will be performed by a small truck mounted rig as pictured below. There will also be an additional vehicle and trailer for transporting extra equipment and consumables such as concrete and sand. As the vehicles are light vehicles only minimal (if any) line preparation will be needed for access. It is expected that most hole / tiltmeter sites will be accessible with no access track preparation at all.

Drill cuttings will be stacked adjacent the hole to be re-used to backfill the holes upon completion of the project.

Installation would typically be completed in a 2 week period.

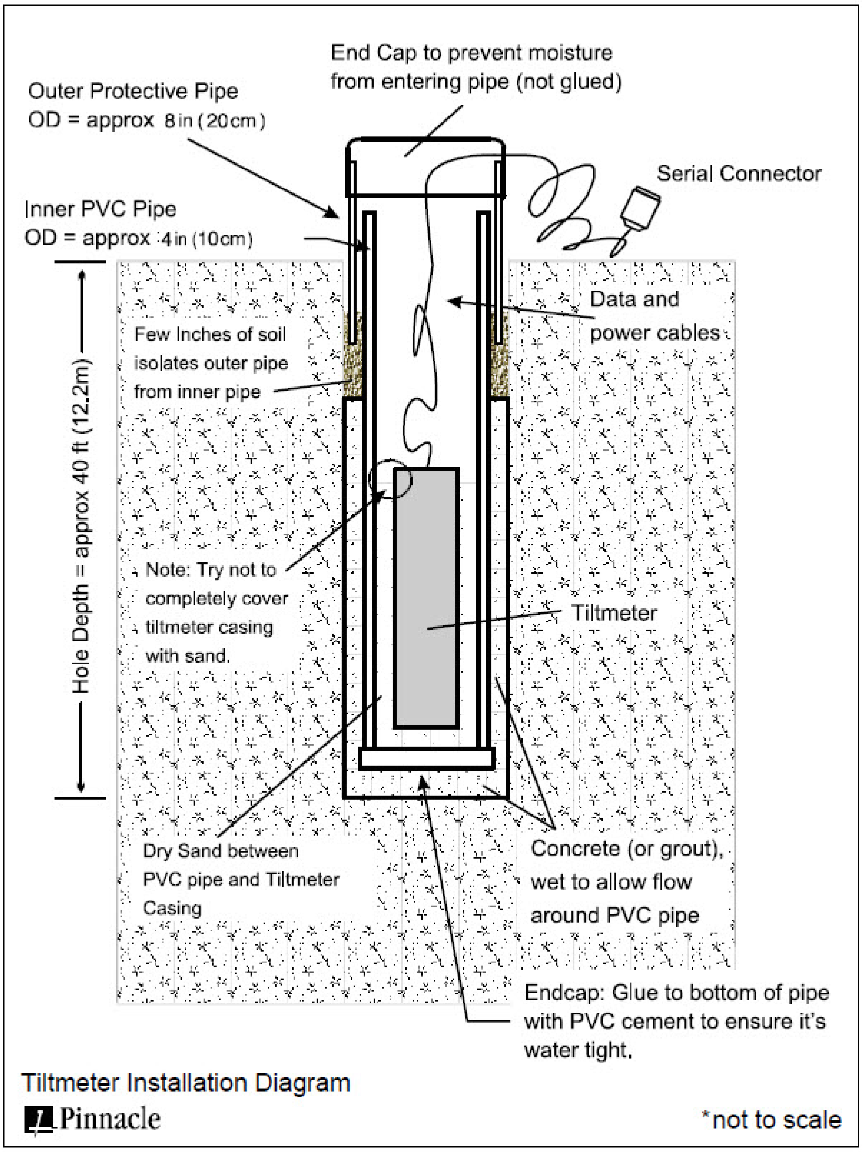


Figure: Schematic of typical tiltmeter installation

Figure: Truck mounted rig preparing shallow hole to install tiltmeter.

Access track preparation

The proposed locations have not yet been finalised but, wherever possible, they will be located close to existing roads or tracks for ease of access. These should all be accessible with no access track preparation. A small number of holes may be required that are remote to existing roads and will need longer cross country travel to reach.

Each hole is likely to only have 2 or 3 light vehicles access it during the installation process.

Should access line preparation be required, the lines will be prepared to the standard of seismic lines and access line preparation will be a conventional approach using a dozer and possibly a grader.

Tiltmeter recording

Once the tiltmeter installation is complete, the meters themselves are basically maintenance free and do not require any revisits until the project is complete and the meters are removed. The tiltmeters are expected to remain in-situ for 2 – 3 months.

Tiltmeter recovery and restoration

Once the tiltmeter survey is complete, the tiltmeters are removed and the location restored. To do this, each site is once again visited by a couple of light vehicles and the meter is manually removed. The outer 8" PVC casing is also removed. The remaining 4" PVC casing is then broken off around 1.2m below ground and the resultant hole is backfilled to ground level using the drill cuttings form the initial drilling if possible.

If any access tracks were prepared, they will be inspected at the time of tiltmeter removal and if required a grader will be brought in to restore the access tracks.

3.4 Fracture Stimulation

Objective

After determining that a well has the required design and well integrity to undergo stimulation and completions, the well is handed over to 'complete' the well and set it up for production. Hydraulic fracture stimulation is not part of the drilling process but is a completion technique applied after the well is drilled. The intent of hydraulic stimulation is to place a highly conductive channel into the reservoir to increase the flow capacity of the well. Typically used in low permeability reservoirs that cannot sustain economic production such as shale. It is a process that has been used in the oil and gas industry since 1947. The Society of Petroleum Engineers (SPE) estimates that over 2.5 million hydraulic stimulation treatments have been undertaken in oil and gas wells worldwide. It has been successfully used on wells in the Cooper Basin for nearly 50 years without a primary barrier breach and is currently performed in many basins around Australia, including the Amadeus Basin in the Northern Territory.

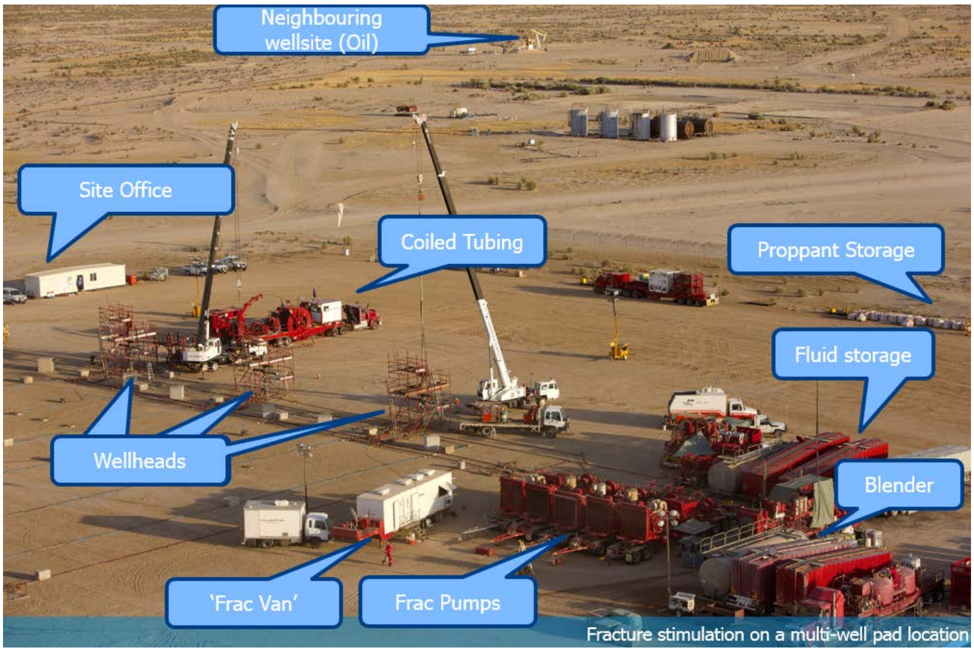
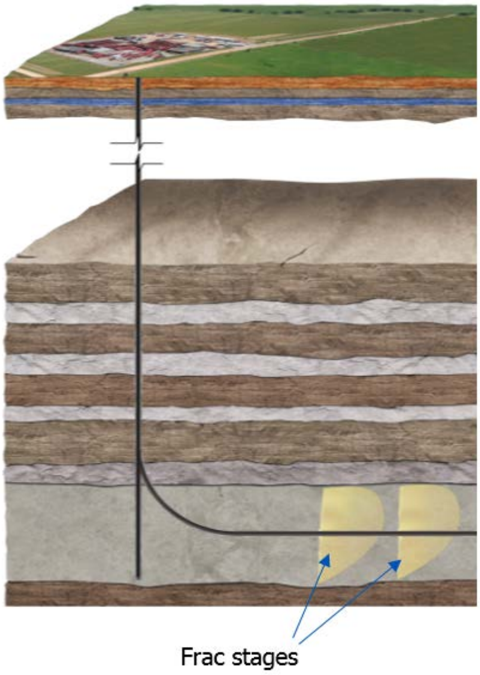


Figure: Fracture Stimulation spread rigged up on a 3-well pad in the Cooper Basin. (Source: Santos 2016)



Vertical depth to proppant placement in hydraulically opened fractures will likely range between 1500m and 4000m below surface.

Figure: Multi stage fracture stimulation operations in a horizontal well.

The stimulation process involves pumping water, a specific blend of chemical additives and a propping agent such as sand or ceramic beads down the well at sufficient pressure to create a fracture in the target formation. Proppant keeps the fractures open once the pump pressure is released which thereby improves the productive potential of the well. A fracture created in deep shale reservoirs, will propagate laterally from the well in a vertical plane. Common dimensional terminology for the created fracture includes fracture half length (xf), fracture height (hf) and propped width (wf), as depicted in the figure below. An unconventional shale gas well typically takes 10 to 15 days to complete hydraulic stimulation operations, with a hydraulic stimulation fluid flowback period of 3 to 90 days, depending on the reservoir and clean up profile, which is typically followed by ongoing flaring and production testing. Production tests may be short if it is possible to put hydrocarbons into existing infrastructure (e.g. Cooper Basin, Surat Basin); however, for exploration wells in frontier basins extended periods (>1 year) of flaring and production testing will be required to establish whether a well or field has the potential to be developed economically

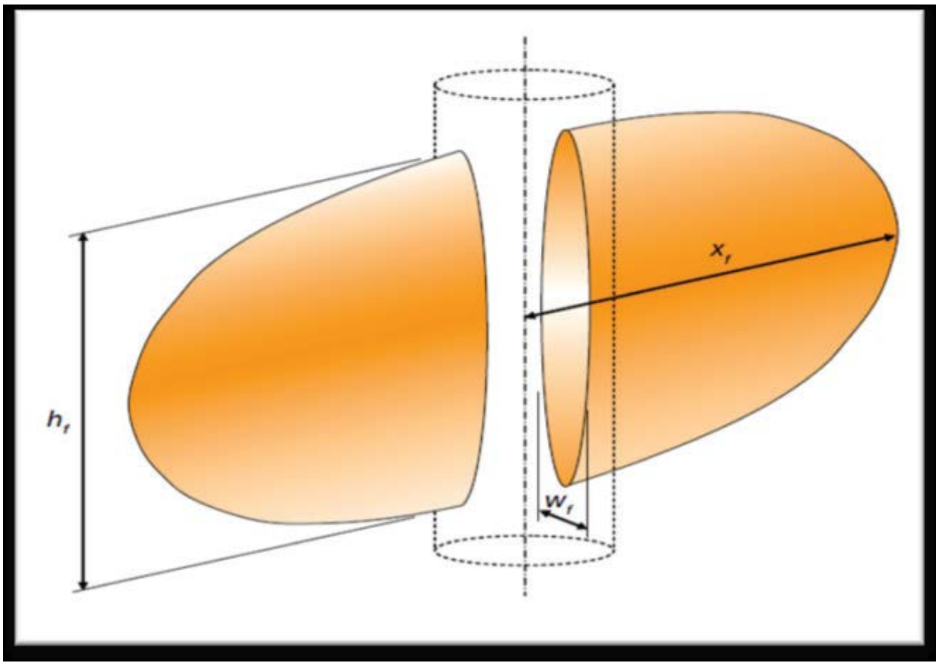


Figure: Conceptualised Shape of Hydraulic Stimulation Zone of Influence. (Source: Economides and Martin, 2007)

Santos has a long history of demonstrated well integrity during hydraulic fracturing operations. In nearly 50 years of hydraulic fracturing operations on over 1,150 wells, there has never been a loss of the primary barrier during the fracture treatment. The primary barrier during the stimulation phase is generally the production casing, with the secondary barrier being the surface well pressure control. Should the primary barrier fail, a pressure relief valve (PRV) installed to monitor pressure between the primary barrier and surface casing, is triggered to open at a pressure well below the failure point of the surface casing. This ensures that the surface casing is not exposed to pressure above its design specification, and as a result prevents the risk of failure. Also, programmable pressure triggers (kickouts) on each of the high pressure pumps will physically shutdown each pump (and associated pressure) if a certain trigger pressure is reached. This trigger is below the design of the well. If the primary barrier did fail during hydraulic fracturing operations, operations would cease and it would be repaired to meet the design requirements before going forward with completing the well again.

Engineering Design

Open hole and cased hole logging provides information required for the hydraulic stimulation design process, including rock stress and lithological parameters. This data is processed using industry-accredited stimulation software to develop an optimal design. The basis of well specific hydraulic fracture design is to create a fracture within the target formation that will produce hydrocarbon through the number of required fractures. This is achieved by modelling fracture length, fracture conductivity, and fracture height for each created fracture as depicted in the figure below. A number of considerations influence the final design for each treatment, including:

- depth and thickness of the formation target
- lithology of formation target and bounding layers
- minimum and maximum horizontal stress across all layers (target and bounding)
- thickness of the seals above and below the target reservoir formation
- porosity and permeability of the formation
- pore fluid saturations (percentage of formation pore volume occupied by oil, gas or water)
- pore fluid properties (e.g. density, water salinity)
- well performance data, including flow rates, formation pressure and produced fluid properties
- formation boundaries (as identified from offset wells, log data, cuttings data, and/or seismic data)
- bulk rock density, elastic properties and compressibility
- natural fracture networks
- stress field analysis to determine the maximum principle stress direction and the minimum principle stress direction

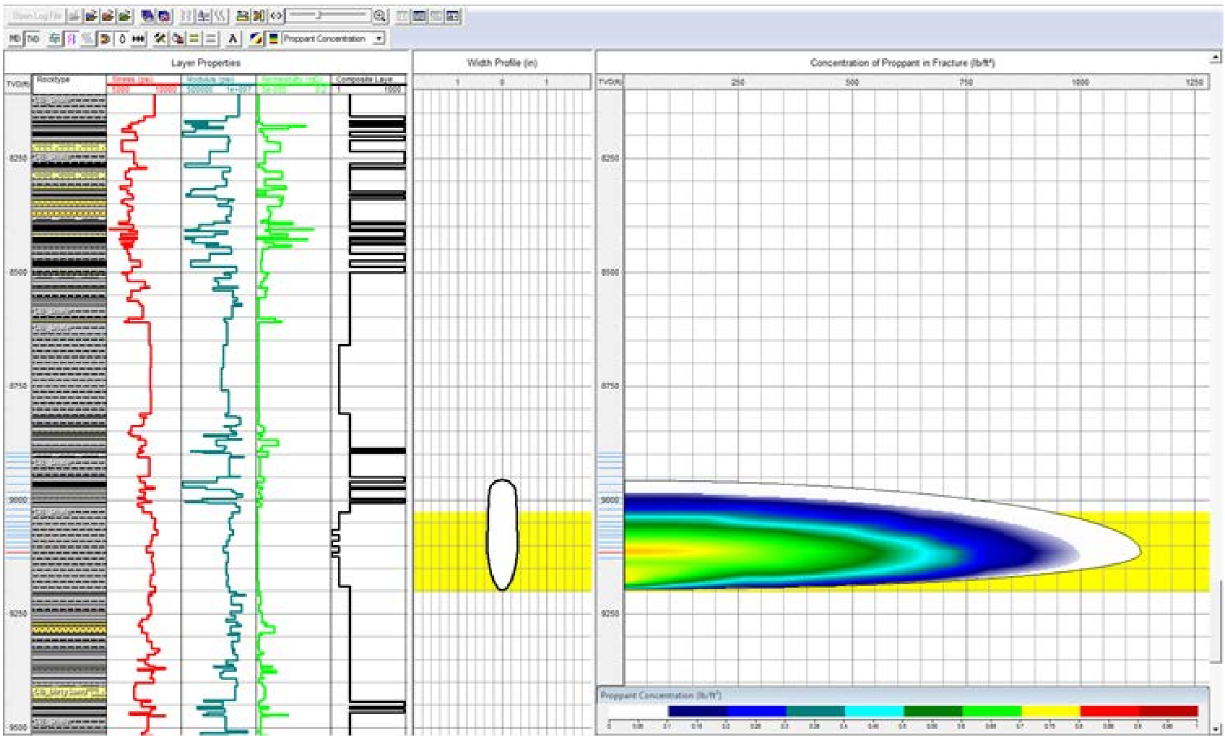


Figure: Modelled side view output from industry accredited stimulation software for a Cooper Basin horizontal well shale hydraulic fracture (Source: Santos 2014)

Proppant and Chemicals

In shale hydraulic stimulation treatments, water accounts for more than 90% of the mixture and sand accounts for about 5-9%. Chemicals generally account for less than 1% of the mixture and assist in carrying and dispersing the sand in the low permeability rock, and ensuring the fluids and formation are compatible and will have the desired physical properties. In accordance with regulatory requirements, chemical additives are subject to full disclosure. The chemical additives are not specific to the hydraulic fracture stimulation process, having many common household uses such as in swimming pools, toothpaste, baked goods, ice cream, food additives, detergents, cosmetics and soap. The chemicals used provide the following functions:

- Viscosity – gelling agents (natural plant based) are added to the water to provide viscosity to enable the proppant material to be transported down the well and into the created fractures.
- Friction reduction – to reduce the force required to pump the fluid, making the fluid more slippery and easier to pump at high pressures and high rates required to create the fracture network.
- Biocide – added to ensure that there are no microbes or organisms present in the water that will affect the gelling agents and to ensure they will not enter and affect the reservoir.
- Scale and corrosion – scale and corrosion inhibitors are added to prevent deposition of mineral scales and to prevent corrosion of the primary wellbore barrier (i.e. the steel casing).

- Surface tension – surfactants or surface tension modifiers are added to assist the flowback of fluids from the formation.

The process is initiated by pumping a pre-designed volume of the stimulation fluid without proppant, referred to as the “pad volume”. The purpose of the pad volume is to create the fracture geometry required to receive the designed proppant volume. Prior to and during pumping the pad into the well, the base gel is prepared and tested using specific QA/QC procedures. Programmed and automated control systems are used to maintain the fluid properties during the pumping of the treatment process. The viscosity of the fluid is typically in the region of 10 to 40 centipoise (cp), depending on the specific fluid design. This may require the use of a base gel or cross-linked gel, both made from guar. In shale fracture stimulation, it is generally possible to use only Friction Reduced (FR) water (instead of a base or cross linked gel), by the addition of a friction reducing agent. This fluid system has the effect of making the fluid slippery to minimise friction pressure lost to the casing.

Figure: Example of a typical slurry gum constituent, guar gum – illustrating its native form, seed form, splits and powder.
*** Note: Guar gum is a vegetable product which is ground into a powder and used to create a viscous liquid for hydraulic fracturing. (Source: Economides and Martin, 2007)*

Once the pad volume has been pumped, the injection of the “slurry stages” begins. Proppant is added to the blender and proportioned into the stimulation fluid. The concentration of proppant generally increases through the slurry stages as designed within the fracture treatment simulator. Previously mentioned chemical additives are incorporated to provide a suitable fluid for transporting proppant into the already created fracture.

In a cross-linked gel fluid system, breaker compounds are added at progressively increasing concentrations throughout the pad and slurry stages. The breaker comprises an oxidizing compound or enzyme that breaks the crosslink sites, as well as the long chain polymers. The end result is a fluid with significantly lower viscosity that can be easily flowed back from the formation to assist with fracture clean-up. The “break time” is designed to coincide with the known pump time at reservoir conditions plus some additional time to ensure the treatment is pumped to completion. This enables the fluid to be more easily recovered from the formation.

Proppant addition begins at low concentrations and is staged up to the final designed concentration which is specific to the formation being hydraulically stimulated. Typical proppant concentrations will range from 0.5 lb/gal (60 kg/m^3) to 8 lb/gal (1000 kg/m^3) for conventional reservoir stimulation, and typically range from 0.5 lb/gal (60 kg/m^3) to 2.0 lb/gal (240 kg/m^3) for shale reservoir stimulation. Proppant used in hydraulic stimulation range from graded quartz sand to higher strength ceramic proppants. The strength of this inert material varies, with ceramic proppant being much stronger than quartz sand. Ceramic proppant is used in formations with higher effective stresses, to prevent it from crushing and losing the created fractures conductive properties.

Figure: Typical sand - guar gum fluid mix. (Source Economides and Martin, 2007)

Once the final slurry stage is pumped on surface, the flush stage is pumped. The flush stage is a friction reduced fluid (non cross-linked) that is used simply to displace the last stage of slurry down to the perforations. This leaves the wellbore volume free of proppant and ensures that the proppant is placed within the fracture. Once this flush volume has been pumped, the high pressure pumps are shut down and the fracture treatment is considered complete. The duration of the treatment is dependent on the specified volumes to be pumped and the rate at which the treatment is pumped, but is typically around 2 hours for a single shale stage treatment.

Perforating

When the formations requiring hydraulic stimulation are identified, the casing needs to be perforated to provide communication between the wellbore and the formation target zone. The type of charge used depends on the type of hole, size and penetration depth required. The three primary types of perforating used are:

- Wireline Conveyed Perforating (WCP) – the most widely used perforating technique in the Cooper Basin. As the name suggests, WCP uses wireline to deploy the perforating charge.
- Tubing Conveyed Perforating (TCP) – uses the same technology as conventional wireline perforating but is run using a coiled tubing unit or jointed tubing (not wireline). TCP is the preferred perforating method when operating in underbalance or overbalanced conditions.
- Hydro-jetting – uses sand and water jetted through small holes in the bottom hole assembly to create holes in the casing across the target formation – there is no perforating charge. Hydro-jetting allows for targeted or pinpoint perforating, creating between 3 and 4 holes per event.

Process

A number of steps are involved in the hydraulic stimulation process to pump the designed fracture treatment:

1. Diagnostic Fracture Injection Test (DFIT) to validate and update the proposed stimulation design. This involves injecting a small volume of water, shutting down the surface pumps and monitoring pressure decline to evaluate near wellbore entry friction, fracture gradient, fluid leak off, and minimum horizontal stress. This stage is optional and typically only performed in the exploratory or appraisal stages of development, or until localised fracture characteristics are defined.
2. Main stimulation treatment consisting of pad volume, slurry stages with increasing proppant concentrations, and flush stage to displace last slurry stage through the perforations and into the fracture.
3. Isolation of the completed fracture stimulation stage using a mechanical plug installed at a pre-designed depth.

4. Perforation of the next stage to be hydraulically stimulated and repetition of the process in steps 2 to 4 above until the final fracture stimulation stage is completed.
5. Removal of all mechanical isolation devices by milling out the mechanical isolations.
6. Flowback well to clean up fracture stimulation fluids and monitor hydrocarbon production. This step may also be combined with an Extended Production Test (EPT) to help define the field reserves and expected production life. The flowback of stimulation fluid is conducted through a separator, which separates and captures liquids, and flares produced gas through a vertical ‘flare stack’.

The above method describes the “plug and perf” technique for fracture stimulation. Another technique is to use coiled tubing assisted annular stimulation which is used to provide a conduit for “pin-point fracturing”. Coiled tubing is run into the well to the deepest target. The bottom-hole assembly run on the end of the coiled tubing incorporates a jetting assembly that allows low concentration sand slurry to cut holes or slots into the casing and cement. The hydraulic stimulation treatment is then pumped into the coiled tubing / casing annulus to initiate and propagate the fracture.

Equipment

The equipment and machinery required to carry out a hydraulic stimulation operation is highly mobile and able to be installed and removed relatively quickly (generally within a couple days). The equipment is designed to comply with state and federal regulations for road transport, and are fitted with safeguards such as an in-vehicle monitoring system (IVMS) to ensure compliance of the individual contractors.

The Wellhead – is used to inject into and control the well, during hydraulic stimulation operations. The stimulation fluids, which are injected from the surface via the wellhead, are injected through the perforations in the well casing under high pressures in order to physically fracture the reservoir rock. The wellhead provides the primary surface barriers for well control.

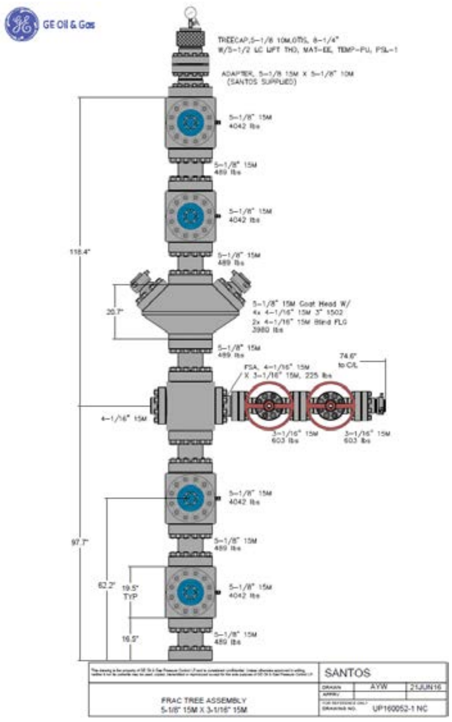


Figure: Typical hydraulic stimulation wellhead used for shale stimulation operations

Above ground storage tanks – on site, above ground water storage tanks provide temporary water storage for use in the hydraulic stimulation process. Source water can either be trucked from a nearby water source or piped along a temporary network. Small dosages of biocide are added to control algal growth particularly under warm and stagnant conditions. Following completion of works, temporary water storage infrastructure is removed from site.

Figure: Above ground storage ponds used for frac make up water storage and frac flowback water storage in the Cooper Basin, (Santos 2013)

Sand Trailer Unit – a large, multi-compartment trailer that holds proppant (sand or ceramic material) required for the treatment. When proppant is required, a conveyor system distributes proppant from the compartments to the blender unit.

Figure: Sand trailer unit. (Halliburton 2012)

Blender Units – In general, two different blending units are used: A pre-gel blender; and a down-hole blender. The pre-gel blender combines the source water with additives required for the base stimulation fluid and proportions of required additives to provide the final hydraulic stimulation fluid. The down-hole blender unit then proportions proppant to the stimulation fluid to provide the proppant concentrations specified in the treatment design. The final hydraulic stimulation fluid, without proppant, is referred to as the "clean fluid". The final hydraulic stimulation fluid, with proppant added, is referred to as "slurry". Chemical additives are precisely measured, controlled and recorded by the blender throughout the stimulation treatment process.

Figure: Blender unit. (Halliburton 2012)

High Pressure Pumps – Reciprocating triplex or quintaplex pumps that receive low pressure hydraulic stimulation fluid from the down-hole blender and inject these fluids at the required higher pressure into the well during the hydraulic stimulation process. 6-20 units are typically used on shale hydraulic fracture stimulation treatments. The pumps contain programmable pressure triggers (kick outs) to prevent pressure from exceeding the wellbore design limits. High pressure treating iron (pipes, manifolds, connectors, etc.) connecting the stimulation pumps and the wellhead also contain pressure safety valves (PSVs) that are set to open at a pre-set pressure to ensure the well components are protected.

Figure: High pressure pump. (Halliburton 2012)

Control or Data Acquisition Unit – telemetry from all units connects to a central control room during hydraulic stimulation treatments. Treatment parameter data, including surface and bottom-hole pressure, pumping rate, chemical rate and fluid density, are monitored, recorded and plotted. Treatment supervisors monitor and control the treatment to ensure that the treatment is pumped according to design. Satellite communication facilities allow further 'remote' oversight by technical experts.

Figure: Control unit. (Halliburton 2012)

Coiled Tubing Unit – a Coiled Tubing Unit (CTU) has many uses within oil and gas operations but is not always required as part of hydraulic stimulation operations. On some occasions the stimulation treatments are placed using coiled tubing assisted annular fracturing, as opposed to "perf and plug" completions (as described above). Coiled tubing can be used in place of wireline jet perforating by jetting holes through the casing and cement using abrasive jetting. Once perforations are jetted, the coiled tubing is left inside the well and the hydraulic stimulation treatment is pumped down the coiled tubing / casing annulus.

In Plug and Perf operations, the Coiled Tubing Unit is generally used at the completion of hydraulic fracturing operations and prior to flowing back into the well, in order to remove or “mill out” the bridge plugs set in the well to hydraulically isolate each stage.

Figure 3.19: Coiled tubing unit. (Halliburton 2012)

Flowback Ponds and/or Tanks – are used to receive fluids produced during stimulation operations and during the initial clean-up phase (following stimulation activities), and potentially during the early weeks and/or months (or possibly longer) of production testing operations. Typically the returning fluid decreases over time until it ceases and a hydrocarbon stream is solely produced. Ponds are typically double lined with UV stabilised synthetic liners to prevent leaks. Typically, after the initial clean-up phase, the produced fluids are allowed to evaporate or treated for disposal or re-use.

3.5 Completion

At the end of the clean-up phase, a workover rig may be used to install production tubing and associated completion equipment such as packers, nipple profiles, tubing hanger, and the production tree. Production tubing which has a smaller internal diameter than casing, is generally required to ensure the well can continue to ‘clean up’ and there is sufficient vertical lift performance to enable fluid to be removed from the well under natural lift from the well. After the well has been “completed” it is ready for longer term production via an inline production network.

3.6 Flow Testing

Once the injection process is complete, the internal pressure of the rock formation causes fluid to return or “flowback” to the surface through the shale gas well. This fluid, often referred to as flowback, contains the dissociation or breakdown products of the injected fluids plus naturally occurring geogenic compounds (i.e. material or substances that are mobilised through the process that must also be considered for any potential health or environmental impact).

A considerable volume of the injected fluids are recovered as flowback. Studies performed by the US EPA (US Environment Protection Agency (EPA), 2004) indicated that approximately 60% of the fluids are recovered in the first three weeks, and total recovery back to surface was estimated to be from 68–82%; however, this is variable across different fields and can be less than 20% in some instances. The flowback water is typically temporarily stored tanks or lined pits before treatment for reuse or disposal.

Initial flowback is typically performed with a mobile separator on location during exploration and appraisal when there are no or limited surface processing facilities. The separator is normally located on the well-pad and connected via relatively short flowlines that include debris catchers and choke manifolds to the wellhead in order to optimise the flowing conditions and frac clean-up. Separators are generally 3-phase which have the ability to effectively segregate gas, oil and water. The gas is sent through to a flare stack where it is flared on location (unless a gas network is already in place), while the liquid hydrocarbon (oil/condensate) is stored in onsite storage tanks, and the water or flowback is stored as described above

Figure 3.20: Flow testing separator rig up on a pad location. (Farley Riggs 2014)

The recovered fluids produced during the initial clean-up phase (following stimulation activities), are stored in Flowback Ponds or Tanks, which are double lined with UV stabilised synthetic liners to prevent leaks. The fluid is allowed to evaporate or it is treated for disposal or reuse in the next hydraulic fracturing event. Waste treatment and management facilities are modular, factory fabricated and transported to site for assembly and connected to piping, electrical controls and instrumentation. By-products from wastewater treatment are contained in fully engineered, purpose built structures for further treatment and disposal. Strategic opportunities for further treatment and beneficial use will be reassessed once composition and technology is assessed. The NT Government will mandate a number of conditions through a Code of Practice that Santos will be required to comply with as a condition of its authorisation to undertake exploration activity.

Fluid samples are taken during the flowback period. The analysed samples are used to determine flow contribution from each of the fracture stimulation stages. Gas sampling is also performed in order to determine the composition of the gas (methane, ethane, butane, carbon dioxide, hydrogen sulphide [not expected], etc.). This will define the value of the product as well as optimising the casing and wellhead material specifications for future campaigns.

Annexure 4 – List of Chemicals Proposed for use in Hydraulic Fracturing of Potential Hydrocarbon Producing Formations

Below is a list of chemicals used by Halliburton, Schlumberger and Condor in Fracture Stimulation operations. If chemicals other than those listed are proposed for use, these will be provided to the NLC and disclosed to Traditional Owners at On Country Work Program meetings.

Chemical Name
1,6-Hexanediol
2-Ethoxy-naphthalene
2-hydroxy-N,N,N-trimethylethanaminium chloride
2-Mercaptoethyl Alcohol
2-methyl-2h-isothiazol-3-one
2-Propenamid (impurity)
2-Propenoic acid, homopolymer, ammonium salt
5-chloro-2-methyl-2h-isothiazolol-3-one
Acetic acid
Acrylamide acrylate copolymer
"Acrylamide, 2-acrylamido-2-methylpropanesulfonic acid, sodium
salt polymer"
Acrylamide, sodium acrylate polymer
Acrylonitrile
Alcohols, C10-16, ethoxylated propoxylated
Alcohols, C11-14-iso-, C13-rich, ethoxylated
Alcohols, C12-15, ethoxylated
Alcohols, C12-16, ethoxylated
Alcohols, C6-12, ethoxylated propoxylated
Alcohols, C9-11, ethoxylated
Alkyl Alcohol
Amides, tall-oil fatty, N,N-bis(hydroxyethyl)
Amine oxides, cocoalkyldimethyl
Ammonium Chloride
Ammonium Persulphate
Ammonium Sulphate
Amylase, Alpha
Benzaldehyde
but-2-enedioic acid
Butyl alcohol
Calcium magnesium sodium phosphate frit
Carbolite (proppant)
Castor Oil
Ceramic (proppant)
Chlorous acid, sodium salt
Choline Chloride
Cinnamaldehyde
Citric acid
Copper(II) sulfate
Cristobalite
Crystalline silica, quartz
Decamethyl cyclopentasiloxane
D-Gluconic acid, monosodium salt
Diammonium peroxodisulphate
Diatomaceous earth, calcined
Dicoco dimethyl quaternary ammonium chloride
Diethanolamine
Diethylene glycol

Diethylene Glycol
Dimethyl siloxanes and silicones
Disodium octaborate tetrahydrate
Distillates, Hydrotreated Light
Diutan
Diutan gum
Dodecamethylcyclohexasiloxane
EGMBE
Ethanol
Ethoxylated branched C13 alcohol
Ethoxylated C11 Alcohol
Ethylene Glycol
Fatty acids, tall-oil, ethoxylated
Formic Acid
Glutaraldehyde
Guar Gum
Hemicellulase
Hydrochloric acid
Hydrotreated light petroleum distillate
Inorganic Salt
Isopropanol
ISP (proppant)
Magnesium chloride
Magnesium nitrate
Magnesium silicate hydrate (talc)
Methanol
N-Benzyl-Alkylpyridinium Chloride
Non-crystalline silica (impurity)
Octamethylcyclotetrasiloxane
Partially neutralized polycarboxylic acid polymer
Pine Oil
Poly(oxy-1,2-ethanediyl), alphahexyl-omega-hydroxy-
poly(tetrafluoroethylene)
Polyacrylamide
Polyethylene glycol
"Polymer of 2-acrylamido-2-methylpropanesulfonic acid sodium
salt and methyl acrylate"
Polyoxyethylene nonylphenol ether
Polyoxyethylene-polyoxypropylene Block Copolymer
Potassium Chloride
Potassium Hydroxide
Potassium persulfate
Pottasium Sorbate
Propan-2-ol
Quartz, Crystalline silica
Quaternary ammonium compounds, bis(hydrogenated tallow alkyl) dimethyl, salts with bentonite
Sand (proppant)
Siloxanes and silicones, dimethyl, reaction products with silica
Sobitan, mono-9-octadecenoate, (Z)
Sodium acrylate, polymer with acrylamide and sodium AMPS
Sodium Benzoate
Sodium bisulfite
Sodium Bromate
Sodium calcium pentaborate octahydrate
Sodium Chloride
Sodium diacetate
Sodium erythorbate

Sodium hydroxide
Sodium iodide
Sodium perborate tetrahydrate
Sodium persulfate
Sodium polyacrylate
Sodium Sulfate
sodium sulphite
Sodium Tetraborate Decahydrate
sodium thiosulphate
Sorbitan monooleate polyoxyethylene derivative
Sorbitan, mono-(9Z)-9-octadecenoate
Sorbitan, monooleate, polyoxyethylene derivs.
Tar Bases, Quinoline Derivatives, Benzyl Chloride-Quat
Tetrasodium ethylenediaminetetraacetate
Tributyl tetradecyl phosphonium chloride
Triethanol amine
Ulexite
Urea

Appendix J: Methane Emissions Management Plan

Santos

Methane Emissions Management Plan: McArthur Basin Hydraulic Fracture Program

NT Exploration Permit (EP) 161

Date	Rev	Reason for Issue	Author	Checked	Approved
16/07/2019	0	Draft	MB	PW	DC

Table of Contents

Tables

Abbreviations and Units

Acronym / Abbreviation	Description
ALARP	As low as reasonably practicable
Code	Code of Practice
DENR	Department of Environment and Natural Resources
DoEE	Department of Environment and Energy
DPIR	Department of Primary Industry and Resources
D&C	Drilling and Completions
EMP	Environmental Management Plan
EP	Exploration Permit
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
EPS	Environmental Performance Standards
ERA	Environmental Risk Assessment
EWCRP	Emergency Well Control Response Plan
ESD	Ecologically Sustainable Development
HFS	Hydraulic Fracture Stimulation
GISERA	Gas Industry Social and Environmental Research Alliance
GHG	Greenhouse gas
km	Kilometre
LEL	Lower Explosive Limit
m	Metres
MD	Measured Depth
MEMP	Methane Emissions Management Plan
MoC	Management of Change
NGER	National Greenhouse and Energy Reporting
NT	Northern Territory
NT EPA	Northern Territory Environmental Protection Authority
OGI	Optical Gas Imaging
PER	Petroleum (Environment) Regulations
SMS	Santos Management System
TOC	Total Organic Content
TPWC Act	Territory Parks and Wildlife Conservation Act 2014
USEPA	United States Environmental Protection Agency
WOMP	Well Operations Management Plan

1.0 Introduction

1.1 Background

Santos proposes to undertake exploration activities in the McArthur Basin in 2019 through to 2020, this Methane Emissions Management Plan (MEMP) is in support of the Hydraulic Fracture Program Environmental Management Plan (EMP).

Under the Petroleum (Environment) Regulations (the Regulations), interest holders in petroleum titles must prepare and submit an EMP. Approval of an EMP is necessary for all activities that have an environmental impact or risk and is only one of several approvals required for the activity to proceed. An approved EMP is a statutory document that is enforceable.

The Code of Practice for Petroleum Activities in the Northern Territory sets out the mandatory requirements for management plans for methane emissions monitoring, leak management, detection and reporting. The Code states that an EMP for a petroleum activity must include a Methane Emissions Management Plan.

1.2 Scope

This MEMP assesses and manages the risks posed by conducting well testing and well completions activities as part of the Hydraulic Fracturing Program at the Tanumbirini-1/2H and Inacumba-1/1H locations. The Hydraulic Fracturing Program EMP does not cover the drilling program scope of work and separate EMPs have been submitted for drilling, civil works and seismic activities.

This MEMP aims to reduce emissions to a level that is as low as reasonably practicable (ALARP) and acceptable via emissions detection and management. The active monitoring and management described below aims to reduce fugitive methane emissions from petroleum activities.

2.0 Activity Description

These activities are restricted to the Hydraulic Fracture program including well testing and ongoing operation of exploration wells. All activities will be conducted as per the requirements of the Code of Practice: Onshore Petroleum Activities in the Northern Territory (the Code). A description of the activity and emissions as well as the control measures used to reduce emissions for each activity is provided in Table 2-1 below.

Table 2-1 Activity and Emissions Description

Activity	Emission Description	Controls
Hydraulic Stimulation	During stimulation, the well will be overbalanced restricting the flow of hydrocarbons to surface.	Well is kept overbalanced to prevent gas influx during and after stimulation. Stimulation fluids kept within the formation after each stage (until flowback).
Flowback and Well Testing	Well is unloaded to allow hydrocarbons and fluid to flow to surface. To minimise methane emissions, flaring will be used rather than venting and venting will only be used where flaring is not feasible All fluids and hydrocarbons diverted to a separator and then hydrocarbons to a flare onsite. Small emissions (<1 tonne) of methane may be released prior to the onset of flaring, as the hydrocarbon production rate may not be enough to sustain a flare initially. Small volumes (kg's/day) of methane is entrained within liquid hydrocarbons and flowback fluid can't be captured or flared and will be released.	Well heads are designed in accordance with the NT Code of Practice and API standards to minimise loss of methane containment. All gas is sent to a separator and then flared. Personal Gas Detector during all operational visits.
Ongoing Well Operation / suspension	Methane emissions restricted to (unplanned) leaks from well heads, including surface casing vents.	Operation staff to carry personal calibrated gas detectors during every routine operational visit to well sites. The Santos Management System Standard 4 – Integrity and Reliability outlines the well integrity procedure. Each well and equipment on a well pad to be inspected every 6 months for leaks using a US EPA Method 21 compliance technique.

2.1 Risk Assessment

An assessment of environmental impacts and environmental risks posed by the hydraulic fracture program has been carried out. This risk assessment includes an assessment of the risks posed by leaks from operating plant. For completeness and consistency with the environmental risk assessment of all activities, this is presented in Section 6 of the EMP. As demonstrated in the risk assessment, the controls identified within the risk assessment and Table 2-1 reduce emissions to ALARP and acceptable.

3.0 Methane Emissions Assessment and Monitoring

3.1 Equipment Selection, Design Standards and Maintenance Practices

All equipment will be selected to minimise the emissions during exploration activities. Exploration wells and associated surface infrastructure will be designed to mitigate leaks in accordance with the relevant standards. The ISO/API standards shown in Table 3-1 have been adopted for the selection of materials for use during 2019 exploration activities in EP-161.

Table 3-1 ISO/API Standards for Material Selection

Component	Applicable Standards
Casing	ISO 11960: Steel pipes for use as casing or tubing for wells.
Couplings	ISO 13679 Procedures for testing casing and tubing connections.
Cement and Additives	API RP 10B-2 Recommended Practice for Testing Well Cements
Drilling Fluids	ISO 10414-1: Recommended Practice for Field Testing Water Based Drilling Fluids. API 13B-1 and 13B-2 Recommended Practices
Well Control Equipment	API STD 53: Blow-Out Prevention Equipment Systems for Drilling Wells. API 16A (ISO 13533): Specification for drill through equipment. API 16D: Specification for Control Systems for Drilling Well Control Equipment and Control Systems for Diverter Equipment.
Wellheads	API 6A: Specification for Wellhead and Christmas Tree Equipment. ISO 10423: Petroleum and Natural Gas Industries - Drilling and Production Equipment - Wellhead and Christmas Tree Equipment

Leak detection equipment will be consistent with the Code including standard leak detection instruments (Section D.5.3 of the Code) as detailed in Section 3.2.1 below. Ongoing well maintenance will be conducted in accordance with the Well Operations Management Plan.

3.2 Methane monitoring methodology and frequency

The monitoring methodology and monitoring frequency in this MEMP is in accordance with section D.5.3 and D.5.2 of the Code.

3.2.1 Methane Monitoring Methodology

Routine inspection aims to detect potential fugitive methane emissions from petroleum activities as soon as practicable so that they can be mitigated. All gas leak surveys will be conducted by suitably qualified personnel using appropriate gas detection instruments calibrated and maintained in accordance with the manufacturer's requirements.

Mandatory inspections will be completed on all surface infrastructure (vents, flanges, valves, connections, drains, pressure relief vents, etc.) of all exploration wells. Leak testing will be undertaken using the United States Environmental Protection Agency (USEPA) Method 21 or optical gas imaging (OGI).

Method 21 uses a portable instrument to detect volatile organic compound leaks from individual sources. If USEPA Method 21 is used, the gas detection instruments, operation and calibration procedures defined in USEPA Method 21 will be followed. If OGI is used for leak detection, the instrument will be capable of imaging a gas that is half methane, half propane at a concentration of 10,000 ppm (by volume) at a flow rate of ≤60 g/hr from a quarter inch (6.4 mm) diameter orifice.

3.2.2 Inspection Frequency

All persons completing emission detection activities will be properly trained. Regular leak inspections will be made to the well sites in accordance with the monitoring and inspection frequencies shown in Table 3-2. If required, previous audit/inspection findings will be used to determine future inspection frequency based on risk.

Table 3-2 Monitoring and Inspection frequency

Activity	Emissions monitoring	Monitoring and Inspection frequency
Hydraulic Stimulation	N/A	N/A
Flowback and Well Testing	• Personal gas detectors • Flared gas will be measured by a flow meter	Ongoing during well testing. All operational personnel will carry and monitor personal calibrated gas detectors during every routine operational visit to well sites.
Ongoing Well Operation / suspension	• Personal gas detectors • USEPA Method 21 or Optical Gas Imaging	6 monthly leak detection. All operational personnel will carry and monitor personal calibrated gas detectors during every routine operational visit to well sites.
All gas containing equipment following major maintenance	• Personal gas detectors	Within 48 hours of recommissioning

3.3 Leak Classification and Response

The leak classification for this Methane Emissions Management Plan in accordance with section D.5.5 of the Code.

3.3.1 Leak Classification

3.3.1.1 Minor Leak

A minor leak is a leak that:

(a) originates from an above ground source;
(b) is an unplanned release;
(c) yields a methane concentration of 500 ppm (by volume) to 5000ppm (by volume) when measured at the surface of the component according to USEPA Method 21; or
(d) any emission visible with an OGI instrument.

Leaks identified during commissioning or bringing equipment back into service are not classified as minor leaks, however they should still be recorded and reported where required under other frameworks such as federal legislation or the incident reporting framework of Part 3 of the Petroleum (Environment) Regulations (PERs).

3.3.1.2 Significant Leak

A significant leak is a leak originating from above ground facilities, gathering systems and subsurface pipelines that meets one of the following criteria:

(a) A leak due to an unplanned release from an above ground petroleum facility that, when measured at the surface of the component according to USEPA Method 21; gives a sustained Lower Explosive Limit (LEL) reading greater than 10% (5000 ppm by volume) of the LEL.
(b) A leak due to an unplanned release from a gathering system - subsurface pipeline that, at ground level; gives a sustained reading greater than 500 ppm (by volume) for a 15 second duration.
(c) A liquid petroleum (condensate / oil) loss of containment that exceeds 200 litres of hydrocarbons.

When it is safe to measure leaks, leaks that are classified as significant leaks during commissioning or bringing equipment back into service should be recorded and reported in accordance with the Code and Section 3.4.

It will be assumed that a leak is above the threshold level for reporting significant leaks if the leak is too large or not safe to measure. Such leaks should be recorded and reported in accordance with the Code and Section 3.4.

3.3.2 Leak Response

3.3.2.1 Leak Response and Notification

In the event of a significant leak Santos will respond with the full cooperation with relevant regulators. The leak response and notification process for a minor leak and major leak is provided in Table 3-3 below.

Table 3-3 Leak Response and Notification

Leak Class	Response	Notification
Minor	All minor leaks will be documented and repaired as soon as practicable, but in any event within 30 days of identification. In the event of the 30 day deadline being unachievable, the Minister will be notified within the 30 days and provided with the reason for the delay and a target date for completion of the work	Will be recorded and reported where required, including reporting requirements under National Greenhouse and Energy Reporting Act 2007 (NGER Act).
Major	Santos's safety management system requirements for risk assessment and emergency response will be followed. Response priorities are as follows: 1) an exclusion zone a will be established around the leak and appropriate restrictions on access to the exclusion zone will be imposed, along with any other necessary immediate controls; 2) the leak shall be repaired or made safe as soon as practicable immediately after detection, as follows; a. the gas leak will be isolated, repaired if possible, contained or otherwise made safe within 72 hours of detection of the leak;	Appropriate notifications will be given to Northern Territory Government departments in compliance with any legislative requirements: 1) along with all other details required under relevant legislation, this notification will include the date of identification, nature and level of leak, operating plant site name, number and location as well as initial

Leak Class	Response	Notification
	b. in the event of the 72-hour repair deadline being unachievable, the reason for the delay and a target date for completion of the work will be submitted to the Department of Primary Industry and Resources before the deadline passes; and c. if it is contended that the risks of immediately repairing a leak exceed the risk posed by the leak, an extension of the 72-hour deadline may be sought if provided that other measures to mitigate the risk are undertaken (e.g. ensuring no ignition sources or personnel are permitted in the exclusion zone). 3) Complying with the other code requirements will not compromise, impair or delay the operator's actions to immediately make the site safe and establish exclusion zones.	steps taken to minimise the risk; and 2) in the case of an emergency situation, a notification to the Department of Primary Industry and Resources' emergency hotline number 1 300 935 250 will be made within 24 hours; The land owner or occupier of the property on which these leaks are occurring will be notified if the leak cannot be repaired immediately.

3.3.3 Remediation Work

Remediation works will only commence work after a suitable risk assessment has been undertaken and relevant safety procedures are followed including consideration of all the required Personal Protective Equipment (PPE) and the Santos Emergency Response Plan.

For leaks identified on well equipment, higher order controls, such as containment by repair, must be implemented wherever possible.

For leaks identified on well casings or adjacent to the well casing (where a work over rig is necessary to effect repair) repairs will be completed as soon as reasonably practicable in consideration of the location of the well, safety to personnel and the public, potential environmental harm, likely access to the well from landholders or the general public, and landholder/community concerns in relation to the leak.

3.4 Emissions Reporting

3.4.1 Leak Reporting

A written close-out report must be submitted within 5 business days of the remediation of the leak, specifying the date of identification, nature and level of leak, location and name of the operating plant, and the rectification actions taken.

If finalising the remediation is delayed more than 7 business days from the identification of the leak an update must be submitted on that day. The final close out report shall be provided when all work is completed.

3.4.2 Greenhouse Gas Emissions Estimates

Greenhouse gas (GHG) emissions for the proposed hydraulic fracture stimulation program were estimated using tools developed for the National Greenhouse and Energy Reporting scheme. Emissions associated with fuel combustion were estimated using factors and formulas in the Emissions and Energy Threshold Calculator – 2018, based on the National Greenhouse and Energy Reporting (Measurement) Determination 2008 (NGER Determination) for the 2017-18 reporting year. The results of these estimates are provided in the EMP.

Emissions from exploration, well construction (including during flowback) and workovers will be measured and reports submitted. These emissions will be measured using methods consistent with the National Greenhouse and Energy Reporting (Measurement) Determination 2008.

4.0 References

USEPA Method 21. US Federal Regulations Title 40 – Protection of Environment Chapter I - Environmental Protection Agency, Subchapter C – Air Programs, Part 60 – Standards of Performance for New Stationary Sources, Appendix A-7 to Part 60—Test Methods 19 through 25E

Santos

Appendix K: Emergency Response Plan

DRILLING AND COMPLETIONS EMERGENCY & WELL CONTROL RESPONSE PLAN

EP-112 Amadeus Basin

EP161 Beetaloo Basin

Campaigns

14 December 2018

Document Control

This document shall be maintained on the Santos Cooper D&C EHSMS SharePoint site. This document is the controlled version and revision announcements will be distributed via e-mail to relevant parties and electronically available on the Santos Emergency & EHS intranet site.

Copies or extracts of this document, which have been downloaded from the Santos intranet site - Discover, are uncontrolled copies and cannot be guaranteed to be the latest version. The person using a hard copy is responsible for ensuring they are using the latest version.

This document must be reviewed at least every three years from last issue for relevance and updated as required and revalidated. Responsibility for the review is with the Onshore D&C Operations Risk Lead.

In addition, relevant plans shall be reviewed where improvement opportunities have been identified by post emergency / incident / exercise debriefs. A review may also be triggered by the handover of major items of equipment, contractor and organisational change.

In reviewing this document, the relevant sites / activities Significant Hazard Risk Register (SHRR) shall be used to assist with the validation of the Plan.

Suggestions for further improvement to the content of this document should be sent to the Document Custodian.

Onshore D&C Operations Risk Lead at:

Cameron.O'Sullivan@santos.com

Document Control and Revision History

Author:

Title	Name	Signature	Date
NT Operations Risk Supervisor	Scott Atkins		13.12.2018

Reviewed by:

Title	Name	Signature	Date
Onshore D&C Operations Risk Lead	Cameron O'Sullivan		21/12/2018
NT D&C Superintendent	Justin Horan / George Nairn		19.12.2018
NT D&C Project Lead	Steve Roberts	Digitally signed by steve.roberts@santos.com DN: cn=steve.roberts@santos.com Date: 2018.12.19 11:36:21 +10'30'	

Endorsed by:

Title	Name	Signature	Date
D&C General Manager	Glenn Watt		21/12/2018

Custodian:

Title	Name	Signature	Date
Onshore D&C Operations Risk Lead	Cameron O'Sullivan		17/01/2019

Revision History

Revision History					
Date	**Rev**	**Description**	**Author**	**Checked**	**Approved**
June 16	0	Issued for use	Steve Pearce	Campbell Blackman, John Easton	Rohan Richardson, Geoff Atherton
Dec 18	1	Aligned to Santos SMS & update campaign details	Scott Atkins	Justin Horan, Cameron O'Sullivan	Glenn Watt

Distribution

Company	Position	Hard Copy	Soft Copy
SANTOS DRILLING AND COMPLETIONS	General Manager		✓
	NT Project Lead		✓
	Onshore D&C Operations Risk Lead (document custodian)		✓
	NT Drilling Engineer		✓
	D&C NT Superintendent		✓
	Operations Risk Coach	✓	✓
	Operating Company Representative (OCR)	✓	✓
NORTHERN TERRITORY GOVERNMENT	Manager DPIR		✓

Note: Uncontrolled copies will be distributed to all contractors at each revision.

1 Contents

Definitions

AME	Aeromedical evacuation (use of a helicopter and/or fixed wing aircraft to medivac)
BUSHFIRE CATEGORIES	Category-1: Fire can be extinguished by person/s that started it at point of ignition, under normal site / activity / emergency response procedures. The fire is in an area of less than a few square meters and is attacked using beaters, tree branches, wets sacks, jackets, etc. Category-2– 5: Fire requires initiation of On-Scene Commander and Field Response Team and may require the Incident Management Team to be activated
CAREFLIGHT	AME provider
CMT	Santos Crisis Management Team A team of nominated Santos senior management based in Adelaide who will where required augment the capability and skills of the Adelaide based IMT. The Crisis Management Team Leader is responsible for coordinating the necessary resources to support the IMT response and recovery efforts.
CMTL	Crisis Management Team Leader
CWCE	CUDD Well Control Equipment
DM (CMT)	Duty Manager (CMT) The responsible person who is "on call" and who initiates the call out of the CMT. The DM is contactable via a central contact number and forms part of a rotational roster
D&C SANTOS SUPPORT REPRESENTATIVE	A person sent to the scene of the emergency or incident if the On-Scene Commander is not available or mobilisation time is extensive. When on site this person is responsible for liaising with and supporting the On-Scene Commander and Contractor Supervisor (D&C) if required. Role is filled by a D&C representative or contractor who is familiar with the operations e.g. a Civils person in a civil contractor's emergency, or a Wellsite Engineer for a well control event.
EMERGENCY	A site/field/area based unplanned event, which requires a response, and which may result in: • injury to people; • loss of control of any aspect; • damage to the environment; • loss of business; • loss or damage to product or assets; • loss of production; or the potential for any of the above
ERN	Emergency Response Numbers. Document containing wellsite contact numbers and directions
EWCRP	Emergency and Well Control Response Plan (this plan)
FRT	Field Response Team Personnel who immediately respond to an emergency at the affected site. Acts under the supervision and guidance of the On-Scene Commander.
FCP	Forward Command Point May be used in a well control event; this will be set up in a prominent but safe location adjacent to the event site. If available, a site office should be used. From the FCP the On-Scene Commander (or well control specialist) directly deploys and supervises resources to manage the event.
INCIDENT	An emergency that has escalated, during which control may be lost to some extent/degree, which requires immediate action to prevent or minimise injury, loss or damage which may give rise to the following to be managed: • generate attention by the media, financial institutions, Government authorities, the public etc.; • the potential for major loss of asset value; • the presumption that the Company is not fit to operate; or • inability to deliver product
IMT	Santos Incident Management Team A nominated group of Santos senior and other support personnel who provide support to the site/field/area in the case of an escalation of an emergency

IMTL	Incident Management Team Leader The individual in overall command, responsible for the management of all incident operations and coordination of the IMT
IOC	Incident Operations Centre The Corporate Head Office location where the IMT and CMT convene (in separate rooms) to respond to an incident
MUSTER CONTROLLER	Person who, in the event of an emergency, conducts a personnel headcount and manages personnel as instructed by the OSC. Undertakes other duties as directed. At some field locations, this may be the first Santos person, or in the event there is no Santos person, the most senior member of a work party who reports to a muster point**.**
NOK	Next of Kin
OCR	Operating Company Representative
OSC	On-Scene Commander Senior person in charge at the scene of the Emergency or Incident and is responsible for directing and supervising all wellsite work and operations in relation to the Emergency at the Forward Command Point (FCP)
PPE	Personal Protective Equipment
RFDS	Royal Flying Doctor Service
SMS	Santos Safety Management System forms the overall framework under which all Santos activities are undertaken
SAR	Search and Rescue
SHRR	Significant Hazard Risk Register
SITREP	Situation Report A communication providing a structured update of the incident and distributed to key stakeholders at regular intervals.
SMEAC	A structured briefing process to communicate information pertaining to an incident. S - Situation M - Mission E - Execution A - Administration & Logistics C - Command & Communication
WELLSITE (SITE)	A well location where work on a well is carried out, or where equipment is situated, stored or is being moved to or from a wellsite under the control of ONSHORE D&C.
STANDALONE OPERATIONS (D&C)	Those drilling and completions activities that are not conducted within a greater Santos operational area such as (e.g.) the Cooper Basin or GLNG.
WELL CONTROL EVENT	A well control event is where the integrity of the wellbore or where drilling, work-over or other well intervention operations are in jeopardy. This event could be a pressure control situation or as catastrophic as a blowout with or without fire. The categorisation of a well control event is as follows: • Level 1 - Standard Well Control Event • Level 2 - Abnormal Well Control Event • Level 3 - Total Loss of Well Control/Fire/Blow-out

1 INTRODUCTION

1.1 Purpose and Scope

This Emergency and Well Control Response Plan (EWCRP) sets out the emergency response arrangements and requirements for Santos Onshore Drilling & Completions (Wellsite) operations to ensure an effective and timely response and recovery to emergency and well related events.

This EWCRP must be implemented when:

- An emergency exceeds wellsite resources
- Well control events relating to:
  - rig operations (drilling, completions, workover, other)
  - non-rig operations (Stimulation, Coiled Tubing, Snubbing, Electric line, Slick line, other well interventions)
  - producing or shutting in wells

This EWCRP is aligned with Santos SMS ST1 – Emergency and Crisis Management Procedure.

1.2 Emergency Response Priorities

The key priorities in all emergencies are based on the PEARL principle:

1. People: Protect human life
2. Environment: Protect the environment
3. Assets: Protect property and assets
4. Reputation: Protect Santos' reputation
5. Liability: Protect Santos' legal exposure

NOTE

- All Santos employees and contractors have the authority to stop relevant activities to follow the above emergency priorities
- Whilst the procedures and processes outlined in this plan should be followed to the greatest possible extent during an emergency response, variations based upon sound management, engineering judgement and operational experience are at the discretion of the respective response leaders
- Activation of the various response teams operates based on prudent over-reaction, accurate assessment and rapid de-escalation

1.3 Related Documents

- SMS-MS11-ST1 – Emergency and Crisis Management
- SMS-MS11-ST2 – Incident Reporting, Investigation and Learning
- Santos Crisis Management Plan (SCMP)
- Well Control Specialist Emergency Response Plans
- Site and Contractors Emergency Response Plans

1.4 Who Uses This Plan

- Santos Onshore D&C personnel
- Santos Incident Management Team
- Other personnel involved in the emergency response

2 ACCOUNTABILITIES

Person	Accountability
General Manager Onshore D&C	• Ensure emergency response arrangements and resources are available for all drilling and completions operations • Ensure this Plan is current and relevant for intended operation • Ensure the relevant D&C organisation is trained and competent to perform the duties as described in this Plan
NT Project Lead	• Ensure that sufficient resources are available at the wellsite in accordance with this Plan • Ensure this Plan is current and relevant for intended operation • Verify that parties with allocated responsibilities are suitably trained and competent for their roles • Maintain the currency and integrity of this Plan and supporting documentation • Ensure that Emergency Response equipment is maintained and available at all times • Ensure Well Control and associated specialist emergency response contracts are in place • Ensure that contractors are aware of and appropriately bridge to this plan
D&C Superintendent	• Oversee the preparedness of contingency equipment as defined in this plan • Coordinate the movement of materials and contractors from the field base to site in an emergency • Assist as required in the field base or at the emergency site • Confirm readiness of D&C sites for emergency management • Ensure the Plan is exercised as per SMS-MS11-ST1 – Emergency and Crisis Management • Assist with drills and training
D&C Responsible Officer (Project D&C Engineer)	• Assist with the maintenance and update of this Plan • Confirm the distribution of the Plan, and readiness of D&C sites for emergency management • Facilitate and participate in training and reviews.
D&C Operations Risk Lead	• Maintain and update this Plan; and ensure consistency with other Santos Emergency Procedures, Plans and Standards. • Support Contract Representatives and Contractors in the appropriate bridging to this plan. Facilitate Plan training and reviews. • Coordinate emergency response debriefs and capture any lessons learnt to improve this Plan. • Ensure that Contractors are aware of and appropriately bridged to this Plan; including resource requirements.
Operating Company Representative (OCR)	• Assist with Plan drills and training and fulfilling requirements of the Onshore D&C Operations Risk Verification Schedule. • Review contractor Well Control shut in procedures. • Issue emergency response numbers to wellsite contractors’

3 ASSESSMENT & ACTIVATION

3.1 Santos Incident Severity Assessment and Activation Matrix

The purpose of the matrix is to determine the level of team support required for an emergency based on the events potential. The matrix is to be used as a guide only.

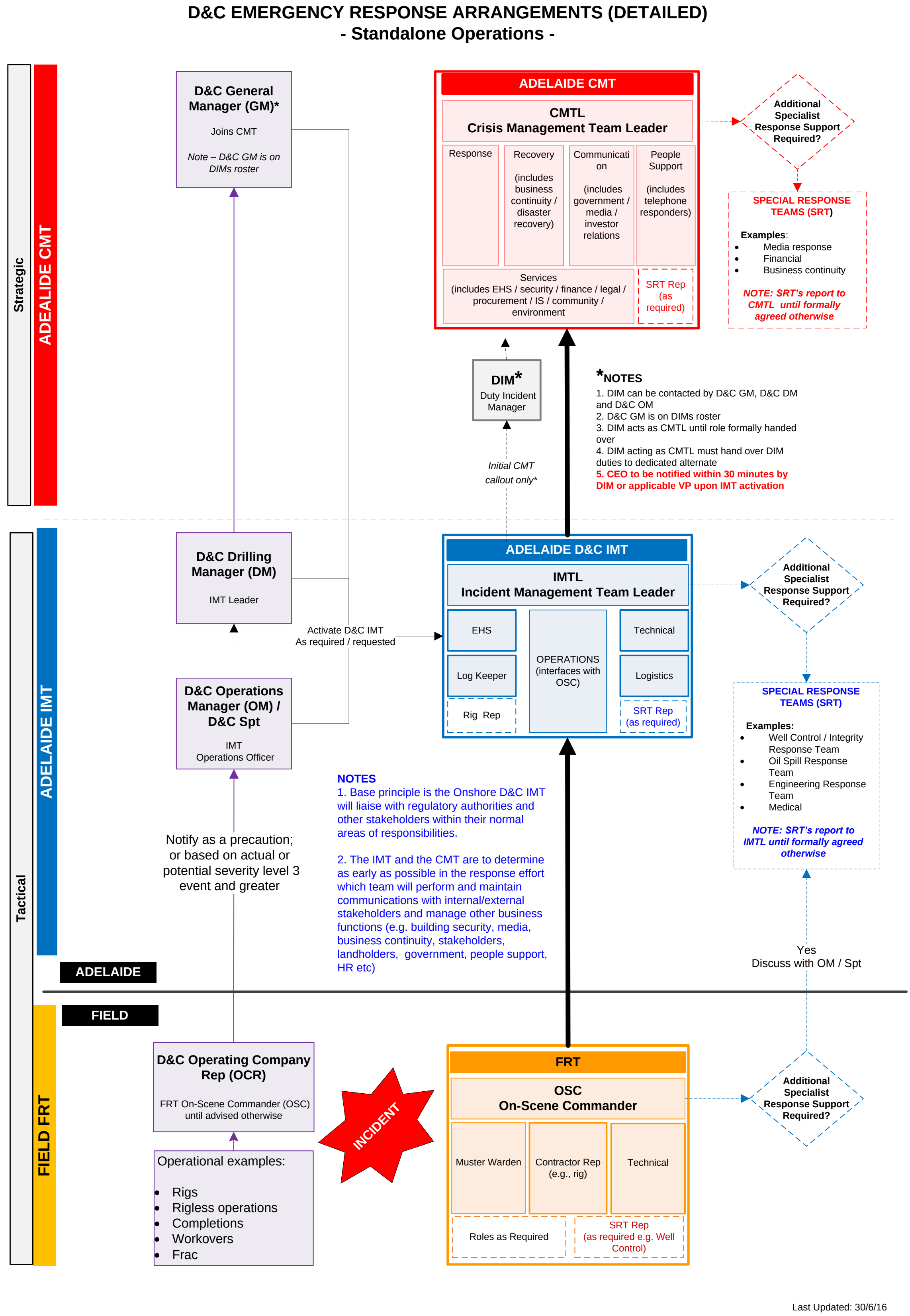
Santos ER Team/s Activation Assessment Matrix

Santos Response Teams	Severity Category (consider actual & potential)	Health and Safety	Well Related	Environment	Reputation & Regulatory
CRISIS MANAGEMENT TEAM; INCIDENT MANAGEMENT TEAM; FIELD RESPONSE TEAM	**5&6**	• Fatality/fatalities • Significant irreversible disability to multiple people	Total Loss of well control (fire; blow-out; etc.)	• Destruction of sensitive environmental features. • Regional and long-term impacts on an area of significant environmental value • Remediation not practical or possible • Regulatory & high-level Government intervention/action • # Category 5 Bushfire	• Shareholders and Board exercise control • National level media exposure • Major litigation or prosecution with damages/fines >$100m plus significant costs • Potential class action
INCIDENT MANAGEMENT TEAM; FIELD RESPONSE TEAM	**4**	• Permanent disabling injury and/or long term off work with high potential to become life threatening • Multiple lost time injuries • High impact process safety incident	• Total Loss of well control (fire; blow-out; etc.)	• Long-term impact of regional significance on sensitive environmental features. • Remediation possible but may be difficult or expensive • Regulatory intervention /action • # Category 4 Bushfire	• Involvement of shareholders • Investigation by regulators • Litigation or prosecution >1m • State level media coverage over several days
INCIDENT MANAGEMENT TEAM; FIELD RESPONSE TEAM	**3**	• Multiple injuries requiring medical treatment, time off work rehabilitation with the potential to escalate • LOC tier-1	• Abnormal well control event	• Short-term impact on sensitive environmental features. • Triggers regulatory investigation • Remediation possible but may be difficult or expensive • # Category 2 & 3 Bushfire	• State level media exposure • Interest by regulator • Major breach of regulation with punitive fines • Involvement of senior management
FIELD RESPONSE TEAM	**2**	• Injury requiring medical treatment with no lost time and rehabilitation • LOC tier 2or any loss of primary containment irrespective of the quantity	• Standard well control event	• Impact on fauna, flora and/or habitat but no negative effects on ecosystem • Readily treated • Requires regulatory notification • # Category 1 Bushfire	• Local media coverage • One or two local complaints • Breach of regulation with investigation or report to authority with possible prosecution and fine
	1	• Minor injury – first aid treatment or no effect • Process safety exception		• Negligible impact on flora/fauna, habitat, aquatic ecosystem or water resources. • Readily dealt with • # Category 1 Bushfire	• No media or community interest • Minor legal issues • Non-compliance and breaches with regulation

Team response activation operates based on prudent over-reaction, accurate assessment and rapid de-escalation.

It is considered better to engage surplus resources up front and subsequently stand down as required.

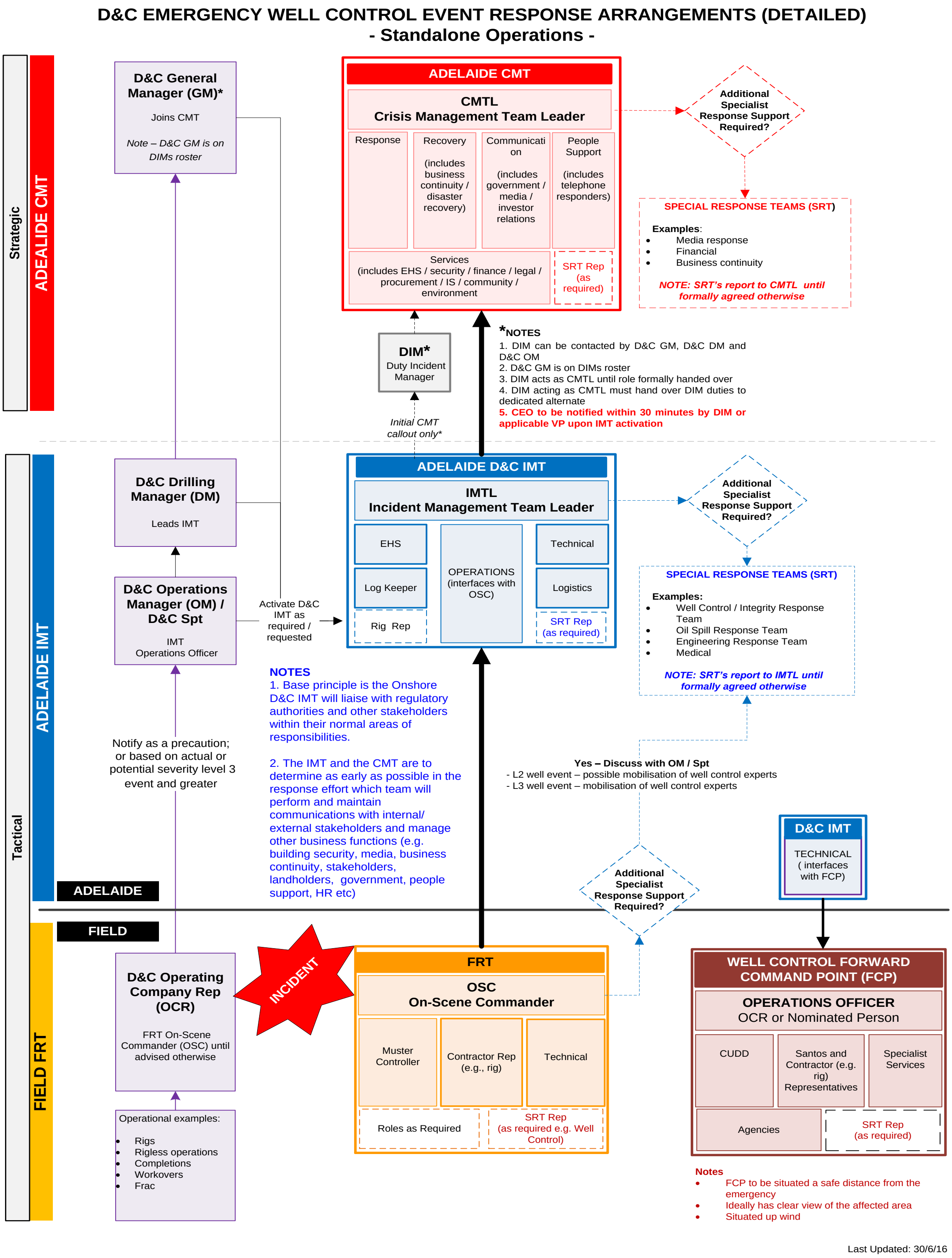
3.2 Emergency Activation Flowchart



Notes:

- The above flowchart should be referenced against the 'Santos Emergency Response Team/s Activation and Severity Assessment Matrix' at s.3.1
- OCR is to ensure the D&C Superintendent and Operations Risk Supervisor &/or Coach are informed of an incident occurring in a timely manner.

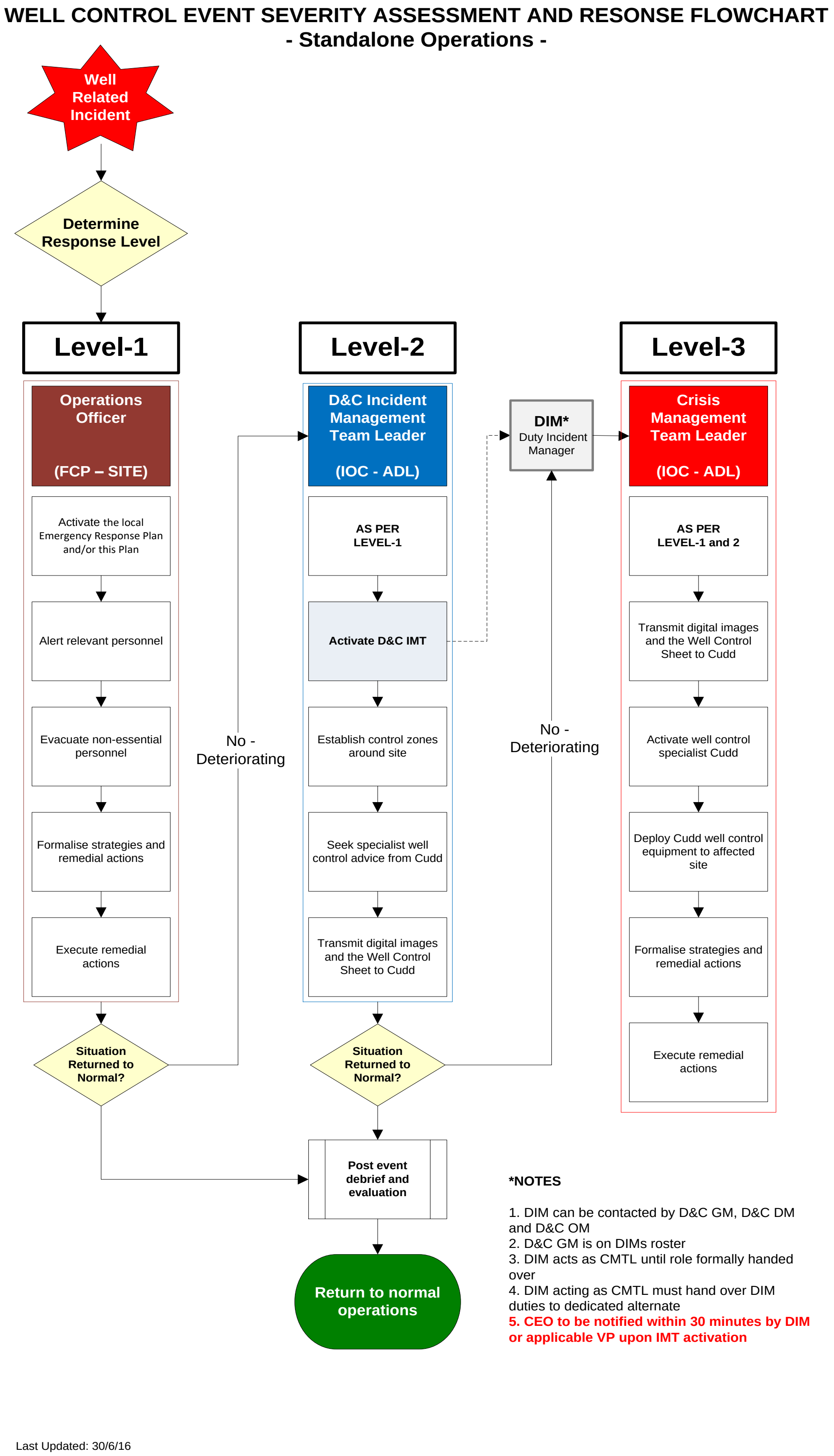
3.3 Well Control Assessment and Activation Flowchart



NOTE

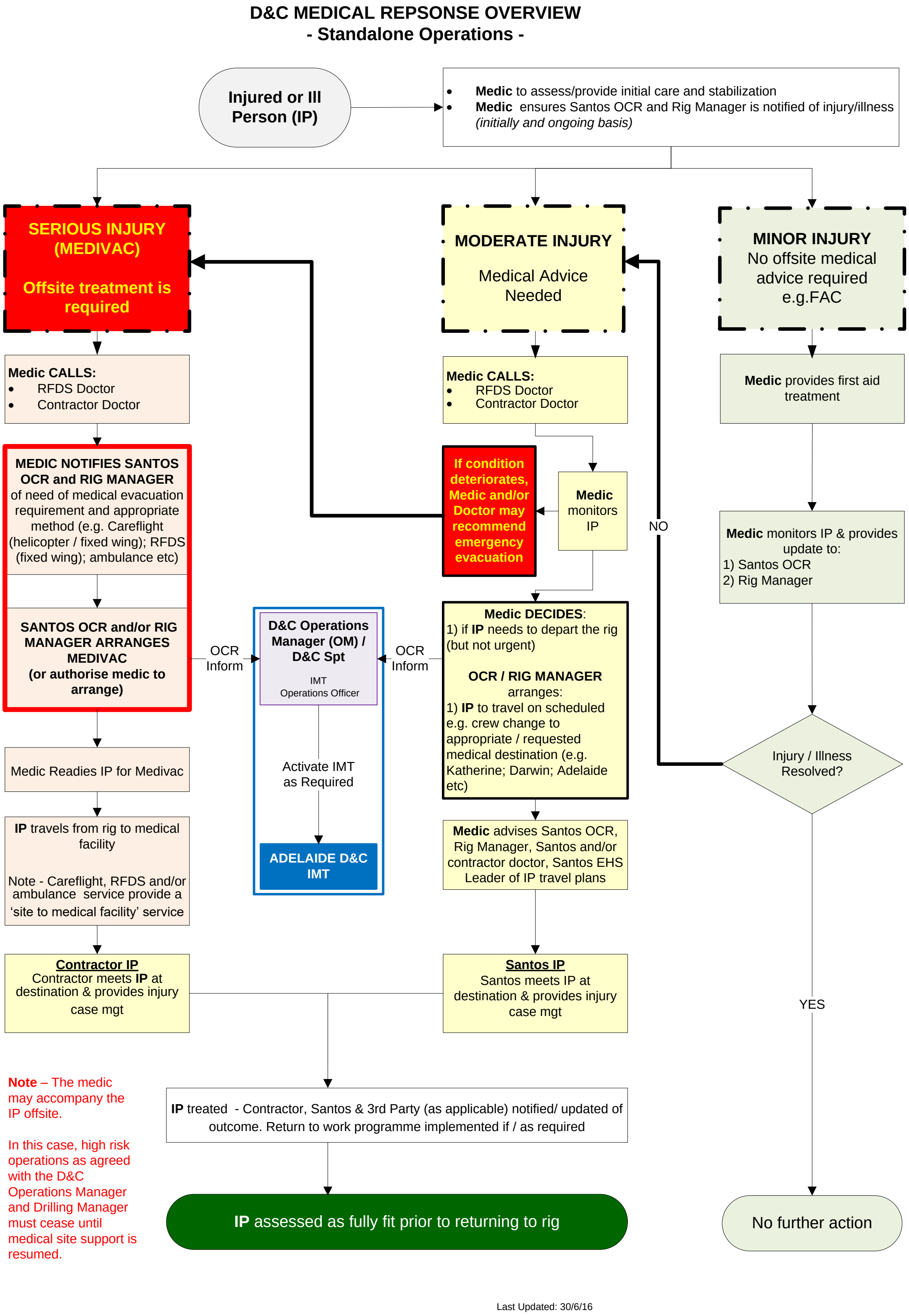
- The above flowchart should be referenced against the 'Santos Incident Management Team/s Activation and Severity Assessment Matrix' at s.3.1
- See s.9.5.1 for well control severity levels, priorities, responses and authorisations

3.4 Assessment and Activation Flowchart – Well Control Severity Level



- See s.9.5.1 for well control severity levels, priorities, responses and authorisations

3.5 Medical Response Flowchart – Overview



Notes

- OCR is to ensure the Santos Superintendent/Operations Manager are timely informed whenever an IP is presented to the medic for a moderate or serious injury issue.
- The medic may accompany the IP offsite. In this case, high risk operations as agreed with the D&C Operations Superintendent and Project Lead must cease until medical site support is resumed.

4 EMERGENCY RESPONSE ORGANISATION

For standalone D&C operations, Santos has a fhree-tiered emergency response structure as per below.

1. Field Response Team (FRT – Northern Territory field location)
2. Incident Management Team (IMT - Adelaide)
3. Crisis Management Team (CMT - Adelaide)

4.1 FRT - Field Response Team (Site)

The FRT is a response team usually situated at the incident site and typically comprises a mix of Santos and contractor personnel appropriately supplemented with technical and other support as required. The FRT is typically led by the Santos Operating Company Representative (OCR).

The Field Response Team (FRT) is typically comprised of the following roles:

- On-Scene Commander (OSC)
- Contractor Supervisor
- Muster Controller
- Medic / First Aid Officer

Notes:

- Except for the OSC (and medic if one is available on site), the FRT members will largely comprise personnel of the principal D&C contractor on site.
- Emergency response duty cards for the Field Response Team are located at s.6 of this Plan.

4.2 IMT - Incident Management Team (Adelaide)

The purpose of the Incident Management Team (IMT) is twofold:

1. To support the FRT by providing required resources, assistance and advice in a timely manner to respond and recover from the incident safely and without undue delay
2. Ensure matters affecting the business and stakeholders are appropriately considered and addressed; typically, in consultation with the CMT

The Onshore D&C IMT is typically comprised of the following roles:

- Incident Management Team Leader (IMTL)
- Technical Officer
- Operations Risk S'visor/Coach
- Operations Officer
- Logistics Officer
- Log Keeper

NOTE

- Base principle is the D&C IMT will liaise with regulatory authorities and other stakeholders within their normal areas of responsibilities.
- The IMT and the CMT are to determine as early as possible in the response effort which team will perform and maintain communications with internal/external stakeholders and manage other business functions (e.g. switchboard, building security, media, business continuity, stakeholders, landholders, government, people support, HR etc.)
- Emergency response duty cards for the Adelaide based D&C IMT are located at s.6 of this Plan.

4.3 CMT - Crisis Management Team (Adelaide)

The purpose of the CMT is to augment the capability of the IMT for a crisis which may have a Santos-wide impact, or which require additional resources to resolve.

The Crisis Management Team is typically comprised of the following roles:

- Crisis Management Team Leader (CMTL)
- Response
- Services
- Log Keeper

- People Support
- Communication

5 EMERGENCY COMMUNICATIONS

5.1 General Guidance to Emergency Response

- Incident Management Team Leader (IMTL) informed of incident and establishes contact with affected site to be provided with details of the incident, understanding of severity and response resource requirements

- Assessment of the emergency and severity is made (based on information from the affected site) and an emergency/incident response level determined

- IMT activated to provide support to the affected site or facilities

- D&C Superintendent attends the IMT (where practicable) and liaises with IMTL to provide technical input and guidance

- IMTL maintains open communications with the affected site - On-Scene Commander (OSC)

- Affected site On-Scene Commander (OSC) supervises the Field Response Team (FRT)

- Other D&C personnel (roles) may be conscripted into the IMT as required

5.2 Wellsite Emergency Response Numbers (ERN)

Maintaining key well information and contact details is critical to ensure a timely response to an emergency.

Wellsite ERNs provided for and available at each wellsite location include the following details:

- Name of the well
- Wellsite and camp site location coordinates and driving route
- Estimated travel distance to the nearest medical support
- Contact details for contractor personnel (mobile phone and satellite phone)
- Contact details of local Santos base (if relevant) and nearest emergency response support facilities

See Appendix s.11 for an example. (Appendix G)

5.3 Incident Notification from Site

The Santos OCR (or in their absence the Contractor Supervisor) is to promptly assume the role of the On-Scene Commander (OSC) and carry out all the functions assigned to that role (see duty card in s.6).

Provide the following information as available (examples below):

Elements	Information Considerations (examples)
Incident type and description	Fire Explosion Well related Injury Vehicle Missing personnel
Incident location	The cross road, landmark or Lat/longs Distance from landmark or identifiable equipment ERN directions and or coordinates
Incident size	Area Height Volume
Details of injuries	Number of injured personnel Description of Injuries Assessment of any medical assistance required
Current status	Has the energy source has been stopped, contained or reduced Level of emergency response required Level/degree of situational control Direction/Movement of hazard (fire) Environmental/Climatic situation (wind, rain etc.)

5.4 Stakeholder Communication and Business Functions

During an emergency it may be necessary to communicate the state/type of the emergency, the possible cause, its effects/consequences, likely duration and impact to all potential stakeholders.

The IMT may be required to liaise with regulatory authorities and other stakeholder groups such as local councils, landowners and emergency services.

All other external Stakeholder Communication is typically managed through the IMC (unless otherwise delegated) and may include (not exhaustive):

- Local landowners and community representatives
- Government agencies and Ministers
- Non-Government Organisations and special interest groups
- Service providers and commissioned agencies
- Santos employees and family members
- Affected contractor management
- Customers and producers
- Media
- Insurers and lawyers

All information that is communicated to external stakeholders must be controlled and authorised by the IMTL and/or the Santos Incident Management Team (IMT)

5.5 Personal Response Log

Individuals who have responsibilities under this Plan are required to maintain personal emergency response log during the emergency. This records key contacts and decisions made during response activities.

When the emergency and recovery is complete, the personal emergency response logs are forwarded to the Onshore D&C Operations Risk Lead. Records relating to the emergency are maintained with the incident investigation records.

D&C operations are provided an emergency log for completion during an emergency event (formatted A4). An emergency response log template is provided in this Plan at Appendix-F in s.11.

6 DUTY CARDS - FIELD RESPONSE TEAM (SITE)

6.1 FRT On-Scene Commander

FRT On-Scene Commander	
Performed By	Santos Operating Company Representative (OCR)
Reports To	IMT Operations Officer Special Response Teams (as activated / agreed)
ROLE	
	• Effective leadership of the Field Response Team • Oversight of field response procedures and activities (Santos and Contractor) • Ensure effective communications are established and maintained with the IMT Operations Officer • Ensures timely and accurate information is being provided to the IMT Operations Officer (if activated). • Ensure that all necessary support is identified and requested via IMT to support the affected site(s) in a timely and effective manner (at time and forecast) • When it is a Santos controlled emergency (e.g. well control) will lead and instruct the Field Response Team • Verify that the contractors Well Control Plan is on site and is suitable
EVERY TEAM MEMBER	
	• Ensure the FRT is set up appropriate to the event • Ensure regular time-outs are called to maintain team wide information accuracy and currency • Look out for the health and welfare of your team members (plan for handovers / change of shifts) • When you have spare capacity, offer yourself to assist the greater response effort • Participate in ER duty handovers; incident debriefing and investigation processes • Do not communicate with the media or transmit information via (e.g.) social media platforms
RESPONSIBILTIES	
Pre-Emergency	• Attend training • Remain familiar with responsibilities within the IMT

Immediate Actions	• Ensure a muster is performed and obtain status of personnel accounted for
	• If required, assist with site muster or evacuation or provision of first aid
	• Establish and clarify details of the emergency (people, environment, asset etc.)
	• Brief all FRT members on factual information and the status of the emergency to ensure FRT members are fully aware of their respective roles and responsibilities
	• Consult with the Operations Manager as to the considered emergency classification level and discuss if the emergency should be escalated up to the Santos Crisis Management Team
	• Consider if Special Response Team support is or may be required and discuss with the Operations Manager
	• Designate an appropriate location to set up the FRT, having consideration for safety and functional operation
	• Ensure that a direct line of communication is established with the IMT
	• Assess with the Contractor Supervisor (D&C) what immediate response can be undertaken by personnel at the wellsite prior to the arrival of further assistance (e.g. Emergency Services etc.)
	• Determine with the Contractor Supervisor (D&C) if outside assistance/external support is required (this should be done on a continual basis)
	• Ensure contractor's field emergency response plans and procedures are immediately implemented
	• Oversee the safe shutdown of equipment/plant in the affected area (if possible) as long as personnel are not endangered in the process
	
	• When emergency alarm is raised, determine the source/type of emergency and gather all available information. The following questions may be useful:
	    • How many casualties if any?
	    • If known, the types of injuries are suspected?
	    • Rescue plans and/or first aid being administered?
	    • Immediate well control measures in place?
	    • Assistance requested or required (internal and external)?
	    • Does the injured person/s normally perform an emergency response role (e.g. Senior First Aider or OSC)?
	    • Will the emergency services be met at a designated location?
	    • Any potential or existing hazards?
	    • Is there any actual or potential impact to the environment?
	    • Are the correct GPS coordinates known for the incident location?
	    • What are the weather conditions?
	    • What are the road/track conditions?
	
	• In the event of a Well Control situation:
	    • See s.9.4 for well control emergency information

	• Locate a Forward Command Point in a prominent but safe location adjacent to the event location. If available, a site office should be used. A staging area should be set up in an adjacent area for personnel and equipment.
	• The staging areas should be set up where there is:
	    ◦ less than 60dB background noise level
	    ◦ access and egress that will not become congested
	    ◦ a triage area, if necessary, for medical personnel in a clearly identified area, but away from all other activities
	• Be responsible for all activities, personnel and equipment. Establish a check-in/check-out system that accounts for all personnel at all times
	• Assign a D&C Santos Support Representative for actions such as log keeper and to act as the focal point of communication to and from the site location
	
	• In the event of a spill, the On-Scene Commander advises the IMT Operations Officer of following details:
	    ◦ Type of product that has been spilt
	    ◦ Location of the spill
	    ◦ Description of the terrain – flood plain, wetlands etc.
	    ◦ How the spill occurred
	    ◦ The size of the spill

During Emergency	• Consider possible length of incident response and make plans to provide handover between teams' roles to allow for breaks and avoid fatigue (etc0 • Provide regular SITREPs to the IMT Operations Officer • Maintain a Personal Response Log recording events/actions/messages/decisions • Arrange regular FRT briefing • Ensure response specific convened meetings (outside of team briefings) are minuted • Assess FRT room conditions and services for any possible EHS matters and rectify as appropriate (fatigue; temperature; congestion; food and drink; noise etc.) • Ensure no information is discarded (as it must be collated at the end of the incident to assist with the investigation) • Lead Field Response Team briefings and keep the team informed on the actions • Ensure group actions, decisions and events are accurately recorded and documented • Continue to assess with the Contractor Supervisor (D&C) what response actions can be safely undertaken at the wellsite prior to the arrival of further assistance (e.g. Special Response Team etc.) • Continue to determine with the Contractor Supervisor (D&C) if outside assistance/external support is required (this should be done on a continual basis) • Support and assist the Field Response Team in the coordination of response support/resources coming to site • Assist in gathering permits that are in use and ascertain what work is currently in progress and what other work may impact on the emergency • If warranted, ensure that the emergency site is cordoned off so that access to the site is restricted to authorised personnel only and if relevant there is no contamination of evidence that may be required • Assist with medical response as able
Post Emergency	• Account for all personnel and ensure the site has been made safe before issuing a stop and stand-down for the emergency • Conduct a debrief with all FRT personnel • Assess the emergency response equipment utilised and arrange for repair/replacement if required • Consult with the FRT team on the status of information, Personal Logs, actions etc. • Ensure that no information is deleted / discarded from status / information boards until all notes have been captured • Ensure information and data is filed for ease of discovery and access • Provide the Incident Management Team Leader and IMT Operations Officer with a comprehensive debrief and report if requested • Participate in the Incident Management Team debrief (if able) • Contribute to emergency post-crisis review • Participate in post incident investigation

6.2 FRT Contractor Supervisor

FRT Contractor Supervisor	
Performed By	Senior Site Contractor Representative (normally the Rig Manager/Toolpusher on location)
Reports To	FRT On-Scene Commander Own company response team leader
ROLE	
	• Responsible for the activation of Contractor Field Response Plans and management of Field Response Team (FRT) • Ensure the safe and effective evacuation of site personnel from the site as required • Ensures that appropriate Emergency Shut Down procedures are implemented • Responsible for communicating with the On-Scene Commander
EVERY TEAM MEMBER	
	• Assemble at the FRT staging location and receive a detailed briefing on the emergency • Maintain Personal Log of events • Ensure regular time-outs are called to maintain team wide information accuracy and currency • Look out for the health and welfare of your team members (plan for handovers / change of shifts) • When you have spare capacity, offer yourself to assist the greater response effort • Participate in ER duty handovers; incident debriefing and investigation processes • Do not communicate with the media or transmit information via (e.g.) social media platforms
RESPONSIBILTIES	
Pre-Emergency	• Remain contactable while on duty • Ensure the wellsite has adequate emergency response equipment and personnel are trained in its use • Ensure adequate numbers of trained First Aiders • Ensure personnel onsite are trained in Field Response Team roles and responsibilities • Understand Contractors emergency response plan, arrangement and requirements • Attend training
Immediate Actions	**The following actions are minimum expectations; they are required to enable Santos Emergency Response Plans to be effective.** **The Contractor Representative must also complete all actions required in their Contractor Field Emergency Response Plan.** • Assume initial responsibility for control of the emergency at the wellsite from a contractor perspective • Ensure contractor's field emergency response plans and procedures are immediately implemented • Establish and clarify details of the emergency (people, environment, asset etc.) • Confirm the source/type of emergency and gather all available information • Ensure a muster is performed and obtain status of personnel accounted for • Establish communications with the Santos On-Scene Commander • Oversee the safe shutdown of equipment/plant in the affected area (if possible) as long as personnel are not endangered in the process • Determine if the situation is static or escalating and any immediate actions being carried out or requirements for support • Ascertain the nature of any injuries that personnel may have sustained • In consultation with the On-Scene Commander, assess what immediate response can be undertaken by personnel at the wellsite prior to the arrival of further assistance • Determine if outside assistance/external support is required (this should be done on a continual basis). If required, the On-Scene Commander will engage the assistance of a local Santos base • Evaluate the situation and agree type of response required including if the emergency requires a Santos controlled field response (e.g. well control) • See s.9.4 for well control emergency information • Ensure any responding agencies have the correct details/location of the emergency and give directions as required • Conduct safe removal of injured personnel to a safe location and administer first aid • Confirm with First Aider what additional assistance may be required • Arrange for the safe shutdown of equipment/plant in the affected area (if possible) as long as personnel are not endangered in the process • Maintain open and regular communications with the On-Scene Commander with current and planned response actions and resource needs • Ensure personnel are responsible for maintaining an events log recording activities / actions / messages / decision. • Assess and manage technical matters relating to the emergency response (e.g. engineering; operational; infrastructure; support services / agencies; repairs / replacement etc.) • Determine requirement for technical information (drawings; PIDs; engineering etc.) and technical resources
During Emergency	• Attend Field Response Team briefings and keep the Field Response Team informed on

	relevant actions • Assess and manage technical matters relating to the Santos response (e.g. engineering; operational; infrastructure; support services / agencies; repairs / replacement etc.) • Determine requirement for technical information (drawings; PIDs; engineering etc.) and technical resources • Establish if personnel are required to evacuate from the wellsite and agree transportation needs with the On-Scene Commander • Continually monitor the site for any other hazards that may be present • Gather permits that are in use and ascertain what work is currently in progress and what other work may impact on the emergency • If warranted, ensure that the incident site is cordoned off so as not to contaminate any evidence that may be required • Monitor the welfare of all personnel at site and ensure that any provisions required are provided (i.e. water/food/shelter) • In consultation with the FRT On-Scene Commander, ensure that access to the wellsite is restricted to authorised personnel only and keep a log of all personnel who enter the location • Act as the primary point of contact for the Emergency Services upon their arrival and provide a detailed briefing on the emergency and known hazards • Formulate a roster for the site if the emergency is expected to require field response over a 12-hour shift/handover period. Ensure a factual briefing/handover for all parties. • Consider what contractors should be put on notice of actual or possible use of their services and discuss with FRT On-Scene Commander • Provide input to briefings to the Field Response Team and other interested parties • Provides technical support to response including well engineering, relief well planning etc. • Liaise with internal and external technical personnel as required (including rig contractor) • Contribute to the development of the response plan • Contribute to the development of the recovery plan • Document all personal actions and decisions on an individual log sheet • Ensure group actions, decisions and events are accurately recorded and documented, and recorded in the Field Response Team Log • Assist with medical response as able
Post Emergency	• Account for all personnel and ensure the site has been made safe before standing down personnel and stating that the emergency has concluded • Follow-up on injured personnel status • Maintain security of the emergency site until an investigation has been completed • Assist in the assessment and integrity of plant/equipment for use after the emergency • Provide the On-Scene Commander with a comprehensive debrief • Consult with the FRT On-Scene Commander on the completion of all necessary internal and external emergency termination communications • Participate in the Field Response Team debrief • Assess the emergency response equipment utilised and arrange for repair/replacement if required • Assist with demob of response / excess equipment and product • Ensure that no information is deleted from status / information boards until all notes have been captured • Ensure information and data is filed for ease of discovery and access • Participate in post incident investigation (as required) • Participate in the FRT debrief (if requested)

6.3 FRT Technical Officer

FRT Technical Officer	
Performed By	Alternate Santos Operating Company Representative (OCR) or Santos Engineer
Reports To	FRT On-Scene Commander
ROLE	
	• Manages engineering and technical support and service activities for the response • Assist in other duties as directed by the On-Scene Commander
EVERY TEAM MEMBER	
	• Assemble at the FRT staging location and receive a detailed briefing on the emergency • Maintain Personal Log of events • Ensure regular time-outs are called to maintain team wide information accuracy and currency • Look out for the health and welfare of your team members (plan for handovers / change of shifts) • When you have spare capacity, offer yourself to assist the greater response effort • Participate in ER duty handovers; incident debriefing and investigation processes • Do not communicate with the media or transmit information via (e.g.) social media platforms
RESPONSIBILTIES	
Pre-Emergency	• Attend training • Remain familiar with responsibilities within the FRT
Immediate Actions	• Establish and clarify details of the emergency (people, environment, asset etc.) • Attend incident FRT briefing • Consider if Special Response Team support is or may be required and discuss with the On-Scene Commander • Assess and manage technical matters relating to the Santos response (e.g. engineering; operational; infrastructure; support services / agencies; repairs / replacement etc.) • Determine requirement for technical information (drawings; PIDs; engineering etc.) and technical resources
During Emergency	• Attend Field Response Team briefings and keep the Field Response Team informed on relevant actions • Liaise with support agencies as directed by the OSC (e.g. RFDS) • Assess and manage technical matters relating to the Santos response (e.g. engineering; operational; infrastructure; support services / agencies; repairs / replacement etc.) • Consider what contractors should be put on notice of actual or possible use of their services and discuss with IMT Operations Officer • Provide technical briefings to the Field Response Coordinator and other interested parties • Provides technical support to response including well engineering, relief well planning etc. • See s.9.4 for well control emergency information • Point of contact for any additional support personnel mobilised to site (technical, engineering etc.) • Liaise with internal and external technical personnel as required (including rig contractor) • Contribute to the development of the response plan • Contribute to the development of the recovery plan • Document all personal actions and decisions on an individual log sheet • Ensure group actions, decisions and events are accurately recorded and documented, and recorded in an FRT Log • Assist with medical response as able
Post Emergency	• Consult with the FRT On-Scene Commander and IMT Operations Officer on the completion of all necessary internal and external emergency termination communications • Participate in the Field Response Team debrief • Assess the emergency response equipment utilised and arrange for repair/replacement if required • Assist with demob of response / excess equipment and product • Ensure that no information is deleted from status / information boards until all notes have been captured • Ensure information and data is filed for ease of discovery and access • Provide the FRT On-Scene Commander with a comprehensive debrief and report if requested • Participate in post incident investigation (as required) • Participate in the FRT debrief (if requested)

6.4 FRT Muster Controller

FRT Muster Controller	
Performed By	Typically, contractor personnel
Reports To	FRT On-Scene Commander Own company response team leader
ROLE	
	• Ensure the safe and effective evacuation of site personnel from the site as required • Maintain information on location and medical status and welfare of mustered personnel • Responsible for communicating with the On-Scene Commander and Contractor representative • Assist in other duties as directed by the Contractor representative
EVERY TEAM MEMBER	
	• Assemble at the FRT staging location and receive a detailed briefing on the emergency • Maintain Personal Log of events • Ensure regular time-outs are called to maintain team wide information accuracy and currency • Look out for the health and welfare of your team members (plan for handovers / change of shifts) • When you have spare capacity, offer yourself to assist the greater response effort • Participate in ER duty handovers; incident debriefing and investigation processes • Do not communicate with the media or transmit information via (e.g.) social media platforms
RESPONSIBILTIES	
Pre-Emergency	• Ensure personnel onsite are trained in Field Response Team roles and responsibilities • Understand Contractors emergency response plan, arrangement and requirements • Attend training
Immediate Actions	**The following actions are minimum expectations; they are required to enable Santos Emergency Response Plans to be effective.** **A person nominated with the responsibilities of Muster Point Warden must also complete all actions at the direction of the Contractor Representative** • Ensure that the muster point is safe to have people congregate • Arrange first-aid for any injured persons at the muster point • Conduct the initial headcount of mustered personnel – compare against site personnel register if possible • Confirm emergency status with Contractor Representative (i.e. ensure the whole site is aware of the emergency and mobilising accordingly) • Communicate headcount result, including details of injured and missing personnel to the Contractor Representative
During Emergency	• Attend Field Response Team briefings and keep the Field Response Team informed on relevant actions • Maintain a log of personnel movements in and out of the muster point (ensure there are no non-essential movements) • Ensure the safe transfer of all muster point personnel to any nominated areas • Update personnel at the muster point with relevant information on the emergency gathered from the Contractor Representative • Report and update relevant emergency information to the Contractor Representative • If warranted, ensure that the incident site is cordoned off so as not to contaminate any evidence that may be required • Monitor the welfare of all personnel at site and ensure that any provisions required are provided (i.e. water/food/shelter) • Assist with medical response as able
Post Emergency	• Pass on stand-down information to muster point, including any no-go areas as directed by the Contractor Representative Attend Field Response Team debrief • Follow-up on injured personnel status • Participate in the Field Response Team debrief

7 DUTY CARDS – INCIDENT MANAGEMENT TEAM (ADELAIDE)

7.1 IMT Incident Management Team Leader

IMT Incident Management Team Leader	
Performed By	Santos D&C Project Lead (or delegate) NOTE – SUPERINTENDENT ASSUMES IMT LEADER ROLE UNTIL DRILLING MANAGER (OR DELEGATE) TAKES OVER
Reports To	Santos Drilling & Completions General Manager
ROLE	
	☐ Effective leadership of the Incident Management Team (IMT) from the Incident Operations Centre (IOC) ☐ Be mindful of the need to <u>lead the response rather than work the response</u> (i.e. broad response overview to be maintained) ☐ Ensure that all necessary support is provided to the affected site(s) to ensure a timely and effective emergency response and recovery outcome ☐ Ensures effective communications are established with all appropriate internal and external parties ☐ IMT / CMT interaction • Activate the CMT as required (via Duty Incident Manager – DIM) • Ensure timely and accurate information is being provided to the CMT (if activated) ☐ **<u>IMT / CMT internal / external notifications and management</u>** ➢ Base principle is the Onshore D&C Incident Management Team will liaise with regulatory authorities and other stakeholders within their normal areas of responsibilities ➢ The IMT and the CMT are to determine as early as possible in the response effort which team will perform and maintain communications with internal/external stakeholders and manage other business functions (e.g. switchboard, building security, media, business continuity, stakeholders, landholders, government, people support, HR etc.)
EVERY TEAM MEMBER	
	• Ensure the IOC is set up correctly • Maintain Personal Log. Do not hoard information - update relevant Information Boards as appropriate before passing Personal Log to the IMT Log Keeper for data capture • Ensure regular time-outs are called to maintain team wide information accuracy and currency • Look out for the health and welfare of your team members (plan for handovers / change of shifts) • When you have spare capacity, offer yourself to assist the greater response effort • Participate in ER duty handovers; incident debriefing and investigation processes • Do not communicate with the media or transmit information via (e.g.) social media platforms
RESPONSIBILTIES	
Pre-Emergency	• Attend training • Remain familiar with responsibilities within the IMT
Immediate Actions	• Consult with the Drilling General Manager and/or On-call Duty Incident Manager (DIM) as to the emergency classification level and determine if the emergency is to be escalated up to the Santos Crisis Management Team • Assemble at the Incident Operations Centre and provide/receive a detailed briefing on the emergency • Establish and clarify details of the emergency (people, environment, asset etc.) • Implement the D&C appropriate ERP • Confirm that IMT members have been contacted and are attending the IOC • Ensure the IOC has been activated and setup • Brief all IMT members on information and the status of the emergency to ensure IMT members are fully aware of their respective roles and responsibilities • For large scale and/or complex incident responses, consider convening Special Response Team/s (SRT) (e.g. well control, spill response team; technical response team; relative response team etc.); noting respective SRTs report to the IMT Leader in the first instance unless otherwise formally agreed
During Emergency	**<u>General</u>** • Be mindful of the need to <u>lead the response rather than work the response</u> (i.e. broad response overview to be maintained) • Maintain current details of the emergency (people, environment, asset etc.) • Hold regular team ‘time-outs’ to gather latest information and ensure each team member is working with the current information • Attend Incident Management Team briefings and keep the Incident Management Team informed on the actions • Contribute to the development of the response plan • Contribute to the development of the recovery plan

Santos

	• Document all personal actions and decisions on an individual log sheet • Ensure group actions, decisions and events are accurately recorded and documented, and recorded in the Incident Management Team Log **Field** (Note – Liaise with IMT Operation Leader as that role interfaces with the FRT) • Ensure regular and effective communications with the On-Scene Commander (OSC) / FRT • Ensure the On-Scene Commander is adequately supported and kept informed of Incident Management Team actions • Confirm the FRT is adequately resourced • Ensure people management strategy is in place (appropriate numbers; fatigue; stress; accommodation; food; etc.) • Confirm the status of Special Response Teams (e.g. Well Control) and other specialist response agencies (e.g. Ambulance; fire fighters; government; etc.) **Agency Reporting** • Ensure designated agency reporting requirements are being undertaken in a timely and in the prescribed manner (if applicable) (e.g. Government; Police etc.). Note – confirm notification arrangements with the CMT so as to not over/double report • SEE COMMENTS UNDER 'ROLE – IMT/CMT INTERNAL EXTERNAL …' **EHS** • For environmental incidents (including spills), ensure the EHS Officer has contacted the Santos Environment department for advice and possible mobilisation to the IOC • Consider possibility of environmental impact – reporting, response, recovery (is a Special Response Team required?). • Ensure actions and plans have been adequately assessed prior to execution from an EHS perspective • Consult on specific regulatory reporting requirements and any commitments Santos has made / is expected to meet • SEE COMMENTS UNDER 'ROLE – IMT/CMT INTERNAL EXTERNAL …' **Medical** • Ensure appropriate medical responses have been activated (if required) (e.g. Santos contracted doctor; specialist people support services such as aeromedical services such as RFDS, CareFlight; hospitals etc.) **Special Response Teams (if activated) (SRT's)** • Maintain engagement with any Special Response Team/s (SRT) that may have been activated (e.g. well control, spill response team; technical response team; relative response team etc.); noting respective SRTs report to the IMT Leader in the first instance unless otherwise formally agreed • For well control events, liaise with the IMT Technical Officer as to status of operations as IMT Technical Officer is the interface with the well response team at the Forward Command Point (FCP) • See s.9.4 for well control emergency information **Administration** • Ensure IMT Log Keeper role is capturing all incident information (electronically and/or hard copy) and being retained (it will be used during the investigation phase) • Establish dedicated phones in IOC for IMT Leader (etc.) • Ensure each IMT member is keeping a Personal Log of events relative to their role **Technical** • Ensure all required information is gathered, response plan devised and being implementing • Ensure role is adequately resource (given possible complex issues to be worked) • Ensure role is provided adequate contracting support to enable plan implementation

Post Emergency	• Ensure that any post emergency communication commitments are completed
	• In consultation with IMT Operations
	    ◦ Ensure that all personnel have been accounted for and that it is safe to resume normal operations
	    ◦ Ensure the affected site and key stakeholders have been provided final emergency communications
	    ◦ Ensure the On-Scene Commander at site provides a detailed debrief report that
	• Liaise with the Log Keeper to ensure that all issues and actions have been recorded in the Log
	• Ensure that no information is deleted / discarded from status / information boards until all notes have been captured
	• Any audio recordings must be labelled, retained and sealed with the Incident Operations Centre confidential files
	• Ensure the termination of the emergency is communicated to all ER personnel (typically IMT and FRT or as agreed with the CMT)
	• Conduct a detailed debrief with the IMT to ensure all issues, actions and lessons learnt are captured
	• Participate in post incident investigation (as required)
	• Assist with the restoration of the Incident Operations Centre and secure filing of all records

7.2 IMT Operations Officer

IMT Operations Officer	
Performed By	D&C Superintendent or Senior Designated D&C Person
Reports To	Incident Management Team Leader
ROLE	
	• OPERATIONS OFFICER ASSUMES IMT LEADER ROLE UNTIL DRILLING MANAGER (OR DELEGATE) TAKES OVER • Responsible for direct communication with the On-Scene Commander throughout response and recovery activities • Gather regular SITREPS on the emergency from the On-Scene Commander • Assist in other duties as directed by the Incident Management Team Leader
EVERY TEAM MEMBER	
	• Ensure the IOC is set up correctly • Maintain Personal Log. Do not hoard information - update relevant Information Boards as appropriate before passing Personal Log to the IMT Log Keeper for data capture • Ensure regular time-outs are called to maintain team wide information accuracy and currency • Look out for the health and welfare of your team members (plan for handovers / change of shifts) • When you have spare capacity, offer yourself to assist the greater response effort • Participate in ER duty handovers; incident debriefing and investigation processes • Do not communicate with the media or transmit information via (e.g.) social media platforms
RESPONSIBILTIES	
Pre-Emergency	• Attend training • Remain familiar with responsibilities within the IMT
Immediate Actions	• Assemble at the Incident Operations Centre and receive a detailed briefing on the emergency • Assist setting up the Incident Operations Centre and ensure an up-to-date 'Emergency Contact' list is available to the Incident Management Team • After initial contact by the FRT, maintain communications and receive ongoing SITREPs • Ensure appropriate communication mediums are available always (i.e. radio / landline / mobile) • Ensure that a direct line of communication is established with the affected site • As requested by the Incident Management Team Leader, communicate with nominated parties and relay messages / instructions given • Obtain contact details (if not on Emergency Contact List) for any external parties involved • Maintain a Personal Log
During Emergency	• Continually review and assess the effectiveness of all communication mediums within the Incident Management Team and with the field and rectify any problems • Ensure the On-Scene Commander is adequately supported and kept informed of Incident Management Team actions • Manage and monitor all event response activities including site evacuation if required • Ensure Emergency Services are briefed, inducted and appropriately guided in their response • Assist in the timely delivery of all correspondence and internal and external communiqués • Assist in the setup of any conference calls with either the affected site or Incident Management Team • Consult with the Incident Management Team Leader to maintain effective liaison with all stakeholders • Review all site SITREPs to assess long term communication issues • Ensure that important correspondence and messages are delivered to Incident Management Team members • Keep Log Keeper informed of any developments at Incident Operations Centre or affected site • Attend Incident Management Team briefings and keep the Incident Management Team informed on the actions • Contribute to the development of the response plan • Contribute to the development of the recovery plan • Document all personal actions and decisions on an individual log sheet • Ensure group actions, decisions and events are accurately recorded and documented, and recorded in the Incident Management Team Log
Post Emergency	• Consult with the Incident Management Team Leader on the completion of all necessary internal and external emergency termination communications • Liaise with the affected site as to final emergency communication issues with all key stakeholders, including the On-Scene Commander and Emergency Services • Ensure that any post emergency communication commitments are completed • Liaise with the Log Keeper to ensure that all issues and actions have been recorded in the Log • Ensure that no information is deleted from status / information boards until all notes have been captured • Any audio recordings must be labelled, retained and sealed with the Incident Operations Centre confidential files • Participate in the Incident Management Team debrief • Assist with the restoration of the Incident Operations Centre and secure filing of all records

7.3 IMT Technical Officer

IMT Technical Officer	
Performed By	Santos D&C Engineer
Reports To	Incident Management Team Leader
ROLE	
	• Manages technical support and service activities for the response • Assist in other duties as directed by the Incident Management Team Leader
EVERY TEAM MEMBER	
	• Ensure the IOC is set up correctly • Maintain Personal Log. Do not hoard information - update relevant Information Boards as appropriate before passing Personal Log to the IMT Log Keeper for data capture • Ensure regular time-outs are called to maintain team wide information accuracy and currency • Look out for the health and welfare of your team members (plan for handovers / change of shifts) • When you have spare capacity, offer yourself to assist the greater response effort • Participate in ER duty handovers; incident debriefing and investigation processes • Do not communicate with the media or transmit information via (e.g.) social media platforms
RESPONSIBILTIES	
Pre-Emergency	• Attend training • Remain familiar with responsibilities within the IMT
Immediate Actions	• Assess and manage technical matters relating to the Santos response (e.g. engineering; operational; infrastructure; support services / agencies; repairs / replacement etc.) • Determine requirement for technical information (drawings; PIDs; engineering etc.) and technical resources
During Emergency	• Attend Incident Management Team briefings and keep the Incident Management Team informed on the actions • Assess and manage technical matters relating to the Santos response (e.g. engineering; operational; infrastructure; support services / agencies; repairs / replacement etc.) • Place major contractors on notice of actual or possible use of their services (ensure Incident Management Team Leader, contracting and legal advice is obtained on communication method and tone of engagement) • Provide technical briefings to the Incident Management Team Leader and other interested parties • Ensure technical associated costs are being recorded and tracked (liaise with finance function to agree data capture arrangements • Provides technical support to response including well engineering, relief well planning etc. • For well control events, act as the interface with the well response team at the Forward Command Point (FCP) • See s.9.4 for well control emergency information • Activates and assembles additional technical support as required • Liaise with internal and external technical personnel as required (including rig contractor) • Contribute to the development of the response plan • Contribute to the development of the recovery plan • Document all personal actions and decisions on an individual log sheet • Ensure group actions, decisions and events are accurately recorded and documented, and recorded in the Incident Management Team Log
Post Emergency	• Consult with the Incident Management Team Leader on the completion of all necessary internal and external emergency termination communications • Liaise with the Log Keeper to ensure that all issues and actions have been recorded in the Log • Ensure that no information is deleted from status / information boards until all notes have been captured • Any audio recordings must be labelled, retained and sealed with the Incident Operations Centre confidential files • Participate in the Incident Management Team debrief • Participate in post incident investigation (as required) • Assist with the restoration of the Incident Operations Centre and secure filing of all records

7.4 IMT Logistics Officer

IMT Logistics Officer	
Performed By	Santos Logistics
Reports To	Incident Management Team Leader
ROLE	
	• Manages Incident Management Team related support and service activities for the response • Responsible for coordinating personnel, equipment, facilities and materials for response operations (including food, shelter, transportation, facilities, security, communications etc.) both for the Field Response Team and Incident Management Team • Ensure that internal and external service needs are met • Assist in other duties as directed by the Incident Management Team Leader
EVERY TEAM MEMBER	
	• Ensure the IOC is set up correctly • Maintain Personal Log. Do not hoard information - update relevant Information Boards as appropriate before passing Personal Log to the IMT Log Keeper for data capture • Ensure regular time-outs are called to maintain team wide information accuracy and currency • Look out for the health and welfare of your team members (plan for handovers / change of shifts) • When you have spare capacity, offer yourself to assist the greater response effort • Participate in ER duty handovers; incident debriefing and investigation processes • Do not communicate with the media or transmit information via (e.g.) social media platforms
RESPONSIBILTIES	
Pre-Emergency	• Attend training • Remain familiar with responsibilities within the IMT
Immediate Actions	• Assemble at the Incident Operations Centre and receive a detailed briefing on the emergency • Confirm the level of activation of the Logistics Group with the Incident Management Team Leader • Mobilise any additional resources or specialist advisors required for the Logistics Group and conduct an initial group briefing where applicable • With the assistance of the EHS, assess need for regulator notification • Consider exclusion zones and road closures • Start and maintain an individual log • Start a status board that captures the status of the emergency response and key activities

During Emergency	• Identify the location and status of off-site equipment and personnel suitable to deal with the issue and coordinate their deployment as required
	• Mobilise personnel to implement exclusion zones and road closures
	• Liaise with the relevant Incident Management Team and staff members to provide transport and care / accommodation for the injured, other employees and relatives if necessary
	• Ensure an overall inventory is maintained of all equipment, materials and supplies purchased, rented, borrowed or used
	• Inform the Incident Management Team Leader of logistical movements (include names and locations)
	• Develop a resource plan in support of the response plan to:
	  ◦ Prioritise needs
	  ◦ Identify alternative resources and supplies
	  ◦ Coordinate delivery / deployment
	  ◦ Ensure actions and plans have been adequately assessed prior to execution from an EHS perspective
	• Attend Incident Management Team briefings and keep the Incident Management Team informed on the actions of the Logistics Group
	• Contribute to the development of the response plan
	• Contribute to the development of the recovery plan
	• Contribute to the Incident Management Team situation reports
	• Document all personal actions and decisions on an individual log sheet
	• Ensure group actions, decisions and events are accurately recorded and documented, and recorded in the Incident Management Team Log
	• See s.9.4 for well control emergency information

Post Emergency	• Consult with the Incident Management Team Leader on the release of all relevant resources, equipment and personnel • Identify any group follow-on actions required and allocate responsibilities and deadlines • Ensure that no information is deleted / discarded from status / information boards until all notes have been captured • Liaise with the Log Keeper to ensure that all issues and actions have been recorded in the Log • Participate in the Incident Management Team debrief • Contribute to emergency post-crisis review • Participate in post incident investigation (as required)

7.5 IMT Log Keeper

IMT Log Keeper	
Performed By	Santos Administration Assistant
Reports To	Incident Management Team Leader
ROLE	
	• Provide advice to assist with ensuring the overall health & safety of all personnel involved in the emergency • Provide EHS support and regulatory advice • Assist in other duties as directed by the Incident Management Team Leader
EVERY TEAM MEMBER	
	• Ensure the IOC is set up correctly • Maintain Personal Log. Do not hoard information - update relevant Information Boards as appropriate before passing Personal Log to the IMT Log Keeper for data capture • Ensure regular time-outs are called to maintain team wide information accuracy and currency • Look out for the health and welfare of your team members (plan for handovers / change of shifts) • When you have spare capacity, offer yourself to assist the greater response effort • Participate in ER duty handovers; incident debriefing and investigation processes • Do not communicate with the media or transmit information via (e.g.) social media platforms
RESPONSIBILTIES	
Pre-Emergency	• Attend training • Remain familiar with responsibilities within the IMT
Immediate Actions	• Assemble at the Incident Operations Centre and receive a detailed briefing on the emergency • Assess room conditions and services for any possible EHS matters and rectify as appropriate (pens/pads etc.; fatigue; temperature; congestion; food and drink; noise etc.) • Set up log keeping arrangements • Inform the Incident Management Team Leader of the need to actively promote the need for each IMT member to complete a Personal Log and provide to the Log Keeper in a timely and ongoing manner
During Emergency	• Arrange meetings and take minutes • Periodically check the information boards for accuracy, that IMT members are recording key information in their Personal Logs, and remind IMT members of the need to hand information to the Log Keeper in a timely manner • Assess room conditions and services for any possible EHS matters and rectify as appropriate (fatigue; temperature; congestion; food and drink; noise etc.) • Ensure each IMT member is adequately stocked with pens, paper, logbooks etc. • Ensure no information is discarded (as it must be collated at the end of the incident to assist with the investigation) • Assist with information filing and data retention • Attend Incident Management Team briefings and keep the Incident Management Team informed on the actions • Ensure group actions, decisions and events are accurately recorded and documented, and recorded in the Incident Management Team Log
Post Emergency	• Consult with the Incident Management Team Leader on the status of information, Personal Logs, actions etc. • Ensure that no information is deleted / discarded from status / information boards until all notes have been captured • Ensure information and data is filed for ease of discovery and access • Participate in the Incident Management Team debrief • Contribute to emergency post-crisis review • Participate in post incident investigation

8 EMERGENCY CONCLUSION

After the emergency has ended and the Incident Management Team and Field Response Team are no longer required, several key issues must be considered when standing down personnel.

These issues relate to ongoing emergency control, investigation processes and recovery actions including appropriate resources for key responsibilities. In consultation with the Santos CMT, final information releases must be considered for affected parties and key stakeholder groups including:

- External Contractors and Services;
- Government Authorities;
- Shareholders;
- Media;
- Employees/employee relatives.

For a Level 3 or above incident, the Incident Management Team and/or the Santos Crisis Management Team will advise all internal and external parties that the emergency is over when:

- Where involved, the Emergency Services have formerly declared the emergency is over and returned control of the affected site back to Santos
- The Incident Management Team declares the emergency has been terminated and the site facilities have been returned to a safe condition
- All people have been accounted for
- Injured persons have been stabilised and / or evacuated
- Effective environmental controls are in place.

The termination of an emergency will be the responsibility of the:

- On Scene Commander for Level 1 and 2 incidents
- Incident Management Team Leader for Level 3 incidents
- Incident Management Team Leader in consultation with the Crisis Management Team for Level 4 incidents
- Crisis Management Team for Level 5 incidents

NOTE All information that is communicated to external stakeholders must be controlled and authorised by the Incident Management Team and/or the Santos Crisis Management Team

8.1 Debriefing

A debriefing is to be conducted by the Project Lead to discuss problems and necessary improvements for incorporation into the emergency preparedness and procedures. Where appropriate, the timing of these debriefs will be co-ordinated in consultation with the Onshore Operations Risk Lead.

This discussion should include:

- Recognition of success and what was accomplished exceedingly well
- Equipment or procedure deficiencies
- Unsafe practices/near miss incidents
- The cause of any injuries sustained
- Unforeseen problems and relevant resolution steps
- Communication/supervision problems
- Environmental considerations
- External problems, i.e. media, landowners, local authority, producers or customers

The minutes from the debrief meeting, when available, will be sent to all attendees.

9 SUPPORTING INFORMATION

9.1 Event Specific Emergency Response Checklists

The following Emergency Situation Checklists can be used by the On-Scene Commander (OCR) and D&C IMT and are located at Appendix B:

- Well Control
- Injury / Fatality
- Electric Shock
- Aircraft Accident
- Bomb / Terrorist / Security Threat
- Bushfire
- Fire / Explosion
- Confined Space
- Person / Vehicle Missing
- Evacuation
- Chemical / Gas Release
- Vehicle Accident
- Helicopter Search and Rescue (SAR)

9.2 Spill Response

Small spills – typically managed locally at the site using dedicated spill kits; which are readily available and appropriately stocked.

Large spills – Typically beyond the capability of site to complete the response. In these circumstances, the OCR is to notify the D&C Superintendent as shown in the Activation and Escalation flowchart at s.3.2. to provide incident details and initiate an appropriately response supported.

All spills will be managed in accordance with:

- This Plan
- Contractors ERP
- SMS-MS1 Risk – ST13 Environmental Hazard Controls Procedure
- Incident & Crisis ST2 - Incident Reporting, Investigation and Learning Procedure
- Project Environment Plan (including regulatory reporting)

9.3 Journey Management Plan

Each campaign is to have a project specific Journey Management Plan (JMP). A copy of the JMP is made available on site.

Contractors will adhere to their own company JMP's as it applies to their operations and personnel, where appropriate.

All vehicles leaving site will be equipped with water, first aid kit and appropriate communication apparatus (e.g. mobile phone, satellite phone).

In the event of an emergency (e.g. overdue arrival; failure to make planned inter-trip contact), a response will be formulated based on collective information known at the time such as last contact location/time, agreed/expected travel route, anticipated driving speed, environmental considerations (e.g. wind, rain, heat) and understood travel hazards (e.g. wild animals, livestock etc.). Assistance to affect a Search and Rescue (SAR) can come from external sources such as the police and the local community (e.g. land holders; local council intelligence etc.).

Overdue arrivals or failure to make contact at agreed points/estimated times will invoke the emergency response arrangements as shown in the 'All Emergency Activations and Escalation Flowchart'.

Santos

9.4 Santos Risk Matrix

CONSEQUENCE		I	II	III	IV	V	VI
	Legal	• Minor legal issues, non-compliances and breaches of regulation	• Breach of regulation with investigation or report to authority with possible prosecution and fine	• Major breach of regulation with punitive fine. • Involvement of senior management	• Litigation or prosecution costing >$1m • Investigation by regulatory body • Litigation involving weeks of senior management time	• Major litigation or prosecution with damages or fines of >$10m+ plus significant costs	• Public inquiry taking up resources and executive time • Major litigation or prosecution with damages/fines of >$100m+ plus significant costs. • Custodial sentence for a manager
	Management Involvement	• Will require some local management attention over several days.	• Event that will require some site-level management time over several days.	• Moderate event that will require the involvement of head office staff and will take up the time of site managers for several weeks.	• Major event that will require considerable senior management time to handle over several weeks	• Long-term severe disruption that requires senior management to devote much of their time and attention for several months	• Prolonged, continuous senior management involvement for over a year. • Operations severely disrupted due to management distraction
	People	• Minor injury, minor medical/first aid treatment or no effect.	• Injury requiring medical treatment with no lost time.	I• Medium term reversible disability to one or more persons. • Significant medical treatment, disabling or lost time injury.	• Extensive injuries or irreversible disability or impairment to one person.	• Single fatality and/or severe irreversible disability to multiple people.	• Multiple fatalities or significant irreversible effects on 10's of people.
	Environment and Community	• Localised and short term environmental or community impact – readily dealt with	• Localised and short term impact to an area, plants or animals of environmental value. • Readily treated • One off community protest requiring intervention and management attention.	• Localised and medium term impact to areas, plants or animals of significant environmental value. • Remediation may be difficult or expensive. • Immaterial effect on community.	• Extensive and medium-term impact to an area, plants or animals of recognised environmental value. • Remediation possible but may be difficult or expensive. • High potential for complaints from interested parties.	• Destruction of an important population of plants or animals or of an area of significant environmental value. • Complete remediation not practical or possible. • Prolonged community outrage that impacts the viability of the business.	• Regional and long term impact on an area of significant environmental value. Destruction of an important population of plants and animals with recognised conservation value. • Complete remediation impossible. • Complete loss of trust by affected community leading to to long-term social unrest & outrage.
	Growth (NPV)	<$150k loss or gain	>$150k, <$1.5m loss or gain	>$1.5m, <$15m loss or gain	>$15m, <$150m loss or gain	>$150m - <$1.5b loss or gain	>$1.5b
	Financial (EBITDAX)	<$30k loss or gain	>$30k, <$300k loss or gain	>$300k, <$3m loss or gain	>$3m, <$30m loss or gain	>$30m, <$300m loss or gain	>$300m loss or gain
	Reputation	• Kept on site. No media or community interest	• Local media coverage. • One or two community complaints	• State media coverage. • Interest by regulator	• State media coverage over several days. • Involvement by regulator and shareholders	• National media coverage over several days. • Shareholders and Board exercise control. • Potential for class action	• Prominent International media coverage over several days. • Long term affect on share price • Changes at executive level. • Shareholders desert stock.

LIKELIHOOD			I	II	III	IV	V	VI
	Almost Certain Is expected to occur in most circumstances or Could occur within days to weeks	f	Low	Medium	High	Very High	Very High	Very High
	Likely Could occur in most circumstances or Could occur within weeks to months	e	Low	Medium	High	High	Very High	Very High
	Occasional Has occurred before in Santos or Could occur within months to years	d	Low	Low	Medium	High	High	Very High
	Possible Has occurred before in the industry or Could occur within next few years	c	Very Low	Low	Low	Medium	High	Very High
	Unlikely Has occurred elsewhere or Could occur within decades	b	Very Low	Very Low	Low	Low	Medium	High
	Remote Requires exceptional circumstances, is unlikely even in long term, 100 year event	a	Very Low	Very Low	Very Low	Low	Medium	Medium
			I	II	III	IV	V	VI

9.5 Well Control Emergency

9.5.1 Well Control Severity Levels, Priorities, Responses and Authorisation

Depending on the nature and severity of a well control event there are three response levels. These levels (detailed below) are an indication of event types that may occur during drilling and completions, petroleum engineering or production activities. For Onshore Australia, if a well is an active or inactive producing well, and a level 1, 2, or 3 event occurs, the well immediately becomes the responsibility of Onshore Drilling & Completions. This responsibility shall remain until the event has been controlled. The well will then be formally handed back to Production. The response levels are intended as guidance and may be upgraded or downgraded as conditions warrant. It should be noted that a conservative approach should be taken, and a higher level of response initiated where appropriate, and downgraded later when deemed necessary.

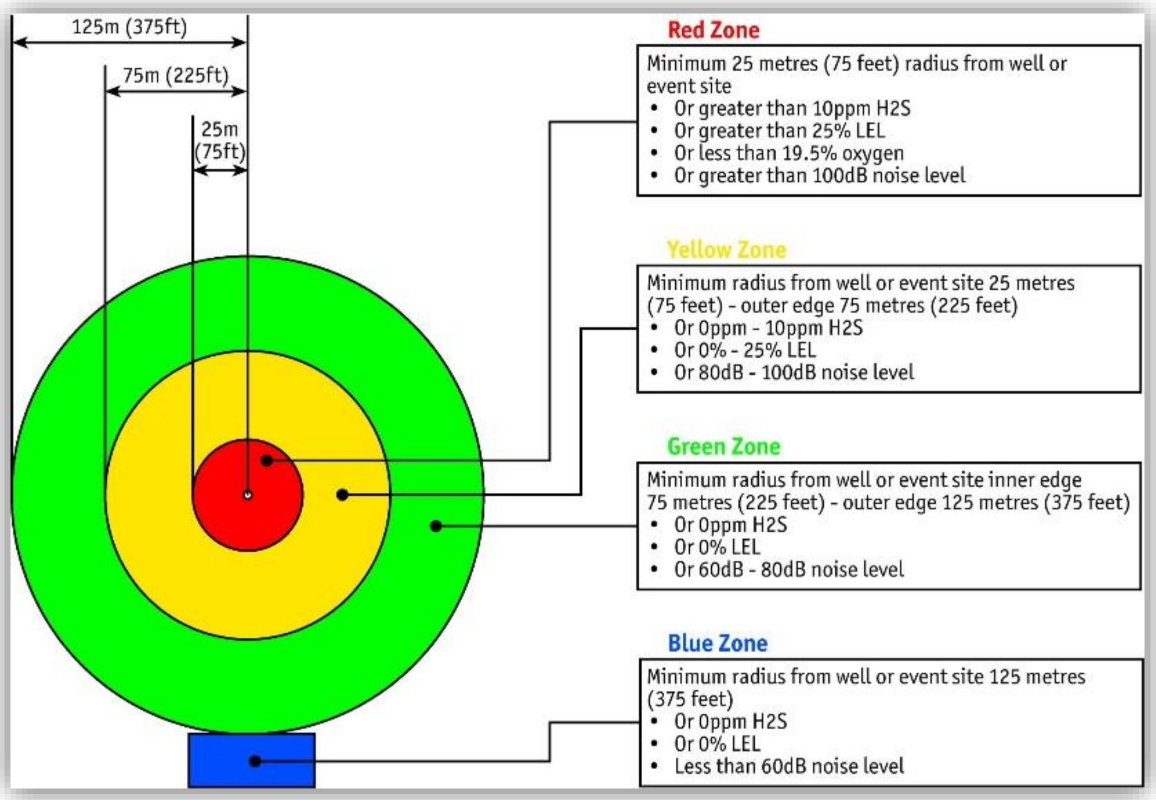
	LEVEL 1 **Well Control Event**	**LEVEL 2** **Abnormal Well Control Event**	**LEVEL 3** **Total loss of well control / fire / blowout**
IDENTIFYING RESPONSE LEVEL	• Fluid standard barrier failed or compromised and unable to be restored, so that well kill is required • Appropriate secondary pressure control barriers are in place and functional • Standard Program or Drilling and Completions Management System kill methods are applicable • Personnel on site adequate for response with support as required (e.g. D&C Superintendent, and D&C Team) • Surface leak or deficiency that is minor or able to be controlled with hydrostatic, wellhead or BOP equipment	• Standard well control method not effective • Non-standard procedure or Well Control Specialist may be required • Repairable leaks or failures in (e.g.) BOP, surface equipment or inside-pipe controls, plugged drill string/bit, or unable to pump, total pump failure • Potential underground flow, unexpected pressures during kill • Abnormal annulus pressure behaviour • Diagnostics and analysis needed • Flaring/diverting where a shut-in would cause loss of control • Gas or liquid handling problems during kill, pit overflows, potential environmental effects • Well flow/pressure during or after tripping, wire line, casing or cementing	A Total Loss of Well Control/Fire/Blowout Event is described where the following conditions exist: • Full scale surface blow-out • Surface well fire • Deteriorating/escalating conditions of abnormal well control event • Well control specialist required • Underground flow confirmed Breaching – major flow of well fluids outside casing to surface
WELL CONTROL PRIORITIES AND RESPONSES	• Activate the local Emergency Response Plan and/or this Plan • Alert and notify all relevant personnel. • Evacuate non-essential personnel. • Use SOPs to formulate and execute the necessary remedial actions.	• Activate the local Emergency Response Plan and/or this Plan; involving office personnel as necessary. • Alert and notify all relevant personnel. • Evacuate non-essential personnel. • Consult Well Control Specialist as required; or mobilise Well Control Specialist • Establish Control Zones around the incident site if necessary.	• The local Emergency Response Plan and this Plan and Santos Crisis Management Plan as determined • Alert and notify all relevant personnel • Evacuate non-essential personnel • Consult with Well Control specialist by transmitting all relevant data pertaining to Discover and the incident • Transmit digital images and Well Control Worksheet to Well Control Specialist via email where possible • Establish Control Zones around the incident site • Mobilise Well Control specialist personnel to site • Deploy Cudd well control equipment
AUTHORISATION TO DECLARE RESPONSE LEVELS	• Santos OCR • Santos D&C Superintendent or Field Coordinator	• Santos OCR • Santos D&C Superintendent or Field Coordinator • Santos D&C Manager	• Santos OCR • Santos D&C Superintendent or Field Coordinator • Santos D&C Manager / D&C Superintendent • Santos General Manager D&C

NOTE - The person at the bottom of each 'authorisation to declare level' is the final authoriser

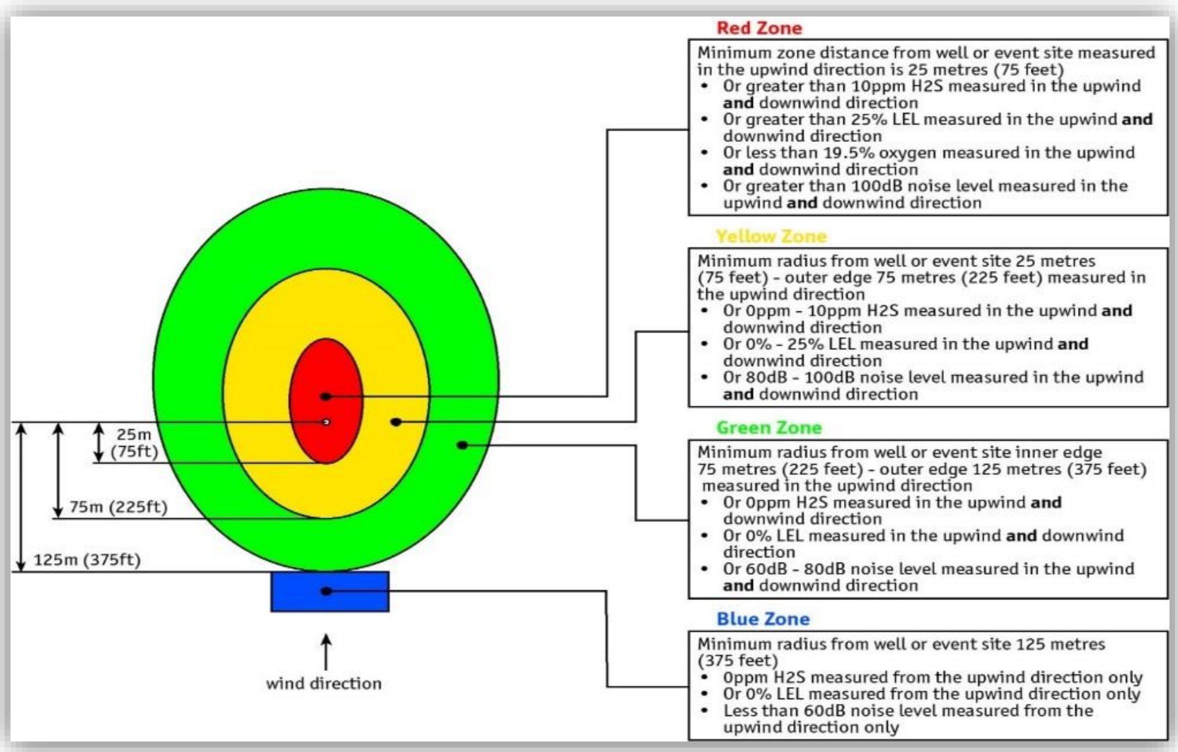
9.5.2 Well Control Operational Area – Safe Distance Overview

The area around Discover/Control event needs to be secured from non-essential personnel and the public. Only essential personnel will be allowed in Discover/Control Operational Area. The area is divided into four different zones. The figures and information in the following diagrams illustrate the layout of a generic Well Control Operational Area based on wind and no wind

Wind conditions could change the shape of Discover/Control Operational Area as shown below. To determine and mark out the extent of each zone a minimum two-person team suited up in appropriate personal protective equipment shall approach the event site from the upwind directions (and downwind only if agreed and practical). Use the information below to place appropriate markers to satisfy each of the minimum criteria listed for each zone. Distances are a guide only and the On-Site Commander shall determine the actual zone distances.



Well Control Operational Area - Not Wind Affected



Well Control Operational Area - Wind affected

9.5.3 Well Control Operational Area – Safe Distance Zones Guide

	BLUE	GREEN	YELLOW	RED
General	• The Forward Command Point would be set up in this area. • The Blue Zone is safe for all personnel and equipment. This zone will be used as a staging area for all personnel and equipment entering the yellow, green and red zones. • This area shall be adjacent to the other well control response zones (Red, Yellow and Green).	• The Green Zone is limited to secondary support personnel. • The On-Scene Commander approves access to the Green Zone and retains an active record of all persons in that zone during a level 3 event. • All personnel entering the Green Zone must sign in at the Forward Command Point upon entering or exiting.	• Access to the Yellow Zone is limited to essential support personnel. • The On-Scene Commander approves access to the Yellow Zone and retains an active record of all persons in that zone during a level 3 event. All personnel entering the Yellow Zone must have the appropriate Personal Protective Equipment (PPE) and must sign in at the Forward Command Point upon entering and exiting	• Access to the Red Zone will be limited to Well Control Personnel and Emergency Services Personnel during Level 3 events. Emergency Services Personnel may include Santos personnel and personnel from external agencies. • The Well Control Specialist will accompany personnel (other than Emergency Services Personnel) into the Red Zone during a Level 3 event. • The On-Site Commander approves entry to the Red Zone and ensures an active record is retained of all persons in this zone.
No wind	• minimum distance from well or event site 125 metres (~ 375 ft.) • or 0ppm H2S • or 0% LEL • or less than 60 dB noise level • access from two directions • large staging area available	• minimum radius from well or event site, inner edge 75metres (~ 225ft), outer edge 125metres (~375ft) • or 0ppm H2S • or 0% LEL • or between 65 – 79 dB noise level	• minimum radius from well or event site inner edge 25 metres (~ 75 ft.), outer edge 75 metres (~ 225 ft.) • or less than 10 ppm H2S • or less than 25% LEL • or between 80 – 100 dB noise level	• minimum 25 metres (~75 ft.) radius from well or event site • or greater than 10 ppm Hydrogen Sulphide (H2S) • or greater than 25% Lower Explosive Level (LEL) • or less than 19.5% oxygen • or greater than 100dB noise level
Wind	• minimum distance from well or event site 125 metres (~ 375tf) measured from the upwind direction • or 0ppm H2S measured from the upwind direction only • or 0% LEL measured from the upwind direction only • or less than 60 dB noise level measured from the upwind direction only • access from two directions • large staging area available	• minimum zone distance from well or event site measured in the upwind direction, inner edge 75metres (~225ft), outer edge 125metres (~375 ft.) • or 0ppm H2S measured in the up and downwind direction • or 0% LEL measured in the up and downwind direction • or between 65 – 79 dB noise level measured in the up and downwind direction	• minimum distance from well or event site measured in the upwind direction, inner edge 25 metres (~75 ft.), outer edge 75 metres (~ 225 ft.) • or less than 10 ppm H2S measured in the up and downwind direction • or less than 25% LEL measured in the up and downwind direction • or between 80 - 90 dB noise level measured in the up and downwind direction	• minimum 25 metres (~ 75 ft.) distance from well or event site measured in the upwind direction • or greater than 10 ppm H2S measured in the up and downwind direction • or greater than 25% LEL measured in the up and downwind direction • or less than 19.5% oxygen measured in the up and downwind direction • or greater than 100dB noise level measured in the up and downwind direction
Typical equipment for L3 event	• portable offices • living quarters • well control support equipment • safety monitoring equipment and personnel • Forward Command Post • Environmental monitoring equipment and personnel	• fire-fighting pump equipment • well kill pump equipment • fluid handling equipment • safety monitoring equipment and personnel • environmental monitoring equipment and personnel	• water monitor stations • Athey Wagon and accessories • bulldozers and operators • cranes and operators •	• Well Control Specialist • Athey Wagon and accessories • specialised fire-fighting equipment • specialised well control equipment

9.5.4 CUDD Information

9.5.4.1 CUDD Equipment - Storage Location

The main cache and two rapid response boxes of CUDD Well Control equipment are located at Moomba (Fire Training Ground).

The CUDD Well Control Equipment has been designed for Santos Onshore Operations in Australia and may be moved to different Santos operations depending on Santos' well programs and activities.

Santos personnel should accompany and deploy the equipment as required.

Refer to Appendices s.11 (Appendix C) for a summary of well control equipment and its storage.

9.5.4.2 CUDD Equipment – Deployment Guide

The CUDD Well Control Equipment (CWCE) shall be available to be mobilised to the event site during any Level 2 or 3 well control event.

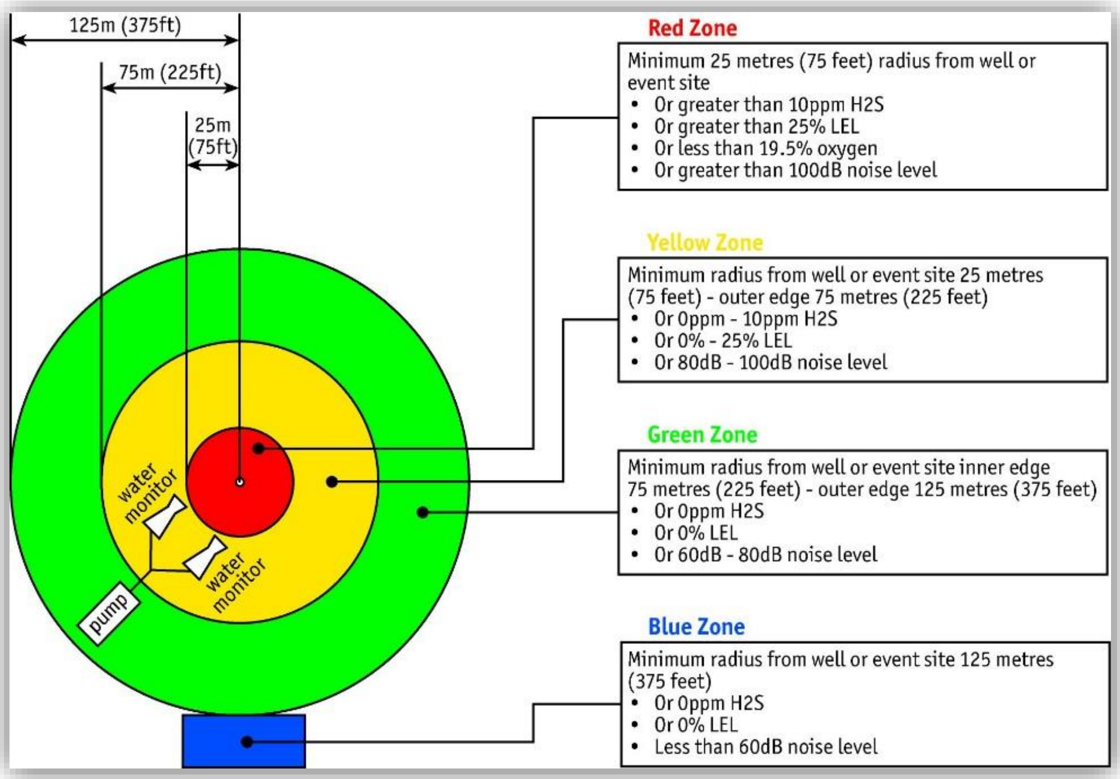


Figure 10.6.4 Generic rig up of Cudd Well Control Equipment

Outlined below are the deployment parameters involved with the deployment of the CWCE.

- Where possible, a Santos supplied well control pump to be used with the Cudd Well Control Equipment.
- Position pump and water source inside of the Green Zone or a minimum of 75 metres (~ 225 ft.) upwind of any hydrocarbon release.
- Secure a minimum of 2,000 bbl. (~ 84,000 US gallons) of fresh water positioned in Stimulation tanks or similar manifold together.
- Use a Stimulation blender capable of producing 1000kpa (~150 psi) at 60bpm (~ 2,500 gpm) to support two monitors.

- A Stimulation blender must use 1 x 100mm (4inch) hose from the blender discharge to the Rapid Response manifold.
- Santos supplied well control pump unit capable of pumping 12 bpm (~ 500 gpm) to support one monitor.
- A pump unit must use 2 x 50mm (2 inch) lines from the pump to the Rapid Response manifold.
- Position the Rapid Response manifold approximately 8 metres (~.25 ft.) inside the Yellow Zone.
- Two monitor hoses (75mm/3 inch) will be required for each monitor. A minimum of 4 x 15 metre (approx. 50 foot) hoses will be needed to position the monitors 30 metres (~100 ft.) from the well.
- Position monitors 15 to 30 metres (~50 to 100 ft.) apart to allow overlapping spray on to the hydrocarbon release.

Note: Under no circumstance is the CWCE equipment to be moved or positioned inside the **Red Zone** without approval from Well Control Specialist.

9.5.4.3 CUDD Equipment – Usage Scenarios

As a precaution, the Cudd Well Control Equipment (CWCE) shall be deployed whenever there is a potential for, or a continuous uncontrolled release of, hydrocarbons at the surface. Used properly the CWCE will lessen the risk of the hydrocarbon release igniting and causing severe damage. The CWCE should be rigged up and used for the three scenarios listed below.

(A) Search and Rescue Operations

The CWCE should be rigged up prior to, and used during, any search and rescue operations around a hydrocarbon release. The search and rescue operation should only be performed by qualified personnel. The CWCE is used to provide protected entry and egress routes for the search and rescue operations.

The personnel performing the search and rescue operations should be covered in water spray at all times. The proper personal protective equipment must be worn by the search and rescue personnel.

After deployment of the CWCE is completed and the operation is discussed with Well Control Specialist, search and rescue operations may begin.

No search and rescue operations will commence inside the **Red Zone** without Well Control Specialist or their designate on location.

No remedial work to the well or its surrounding equipment should be performed in the **Red Zone** without Well Control Specialist or their nominee on location.

(B) Uncontrolled Hydrocarbon Release

The CWCE should be used during an uncontrolled release of hydrocarbons as an ignition suppressant agent.

The CWCE will be able to provide a water deluge on the release to lessen the risk of ignition.

(C) Ignition of Hydrocarbon Release

After ignition of an uncontrolled hydrocarbon release, the CWCE should be used to lessen the damage to the rig and/or surrounding equipment.

Proper use of the CWCE should contain the fire and reduce the severe heat loading on the rig, thereby lessening the damage.

9.6 Road and Air Considerations

9.6.1 Response to an Emergency - Road

Where emergency services such as ambulance, police and fire services are dispatched by road, a Santos employee or contractor will meet the emergency service at a designated location.

9.6.2 Response to an Emergency - Helicopter

The helicopters in Onshore D&C Operations can be utilised to transport personnel and equipment for field emergency responses and medivac operations.

The following steps detail the safe operational considerations and procedures required for setting up landing areas for helicopters at an incident site.

9.6.3 Approaching the Aircraft Safely

- Always approach helicopter from side and remain outside of rotor path.
- Before approaching aircraft extend right arm sideways with thumb extended upwards. When the pilot wants you to approach he will in turn give the thumbs up signal.
- Do not approach helicopter from the front or rear
- Do not proceed past rear locker on fuselage.
- Remove hats and secure or remove loose clothing when approaching the helicopter and when indicating wind direction.
- Never approach helicopter through the danger zones indicated in the figure below:

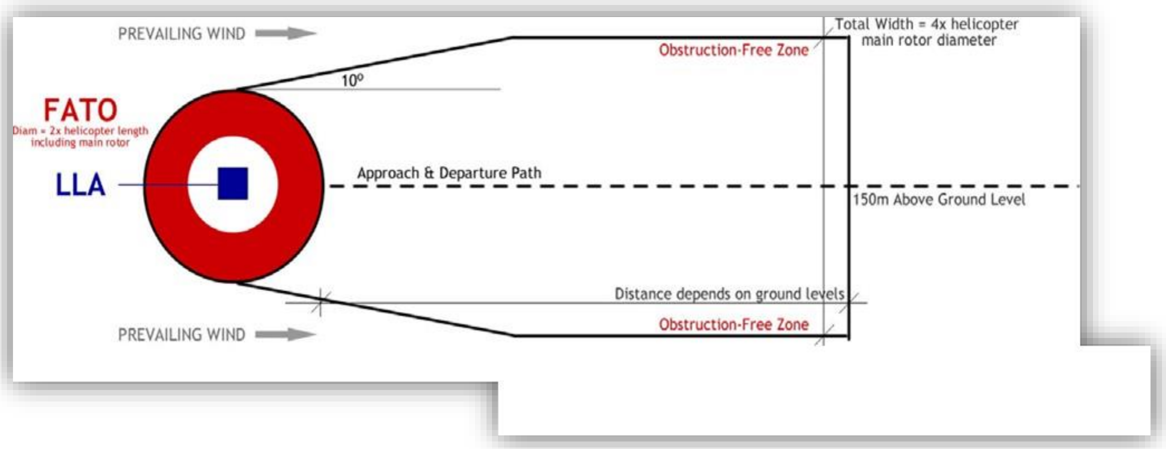
Helicopter Safe Approach

9.6.4 Preparing for Landing / Take-Off

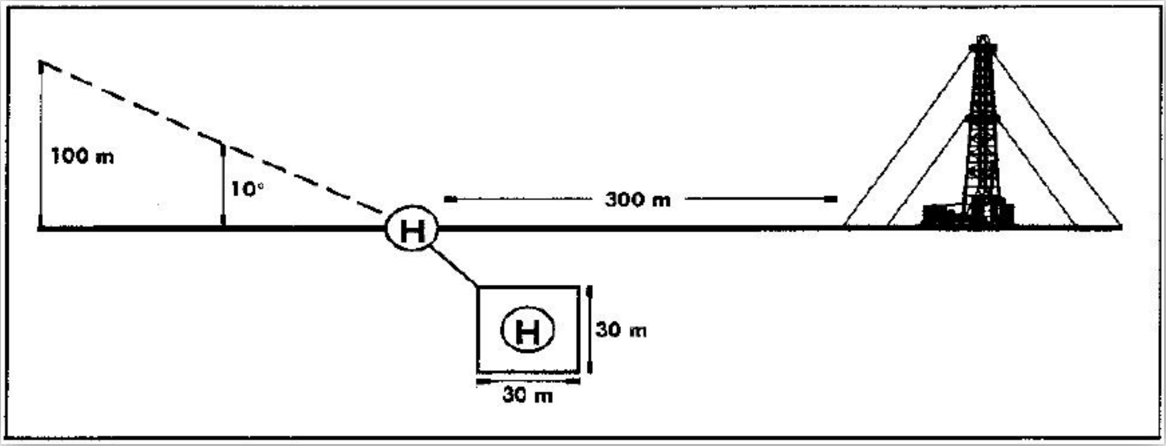
- Coordination of location and preparation of landing sites for rotary and fixed wind aircraft is the responsibility of the Santos OCR.

- Have a Final Approach and Take Off (FATO) area large enough to accommodate the helicopter safely – a circular area of 30m diameter (or equal to twice the length of the helicopter, when the rotor(s) are turning); free of obstacles; no loose materials or any rubbish likely to interfere with the operation of the helicopter.
- When preparing landing strip ensure area is clear of moveable debris.
- Never site helipad in an area with more than a 7.5^0 degree slope (this is reasonably flat ground - 1:8 vertical to horizontal).
- If possible, water down the landing pad as this will reduce the dust problem.
- Never land a helicopter in an area where scrub is higher than 0.5 metre as the tail rotor could sustain damage.
- Ensure flight path for take-off and landing does not require helicopter to pass over power or phone lines, trees, buildings, or vehicles.
- If possible, do not use a road as a landing pad, particularly if the road has poor visibility, bends, or T-junctions.
- Ensure wind socks are in place, or flags flying to indicate wind direction. If no wind sock or flag on location, stand with back to wind and arms outstretched at ten to two positions. Situate other members of the party 5 metres behind you crouching, kneeling, or sitting.

NOTE - Helicopter rotor blades are very finely balanced and even a light object such as a plastic bag drawn up into the rotor disc can cause major damage. Additionally, loose objects may be drawn into the engine air intakes causing catastrophic engine damage.



Final approach and take off area for helicopter



Layout for Helipad

9.6.5 Response to an Emergency – Fixed Wing

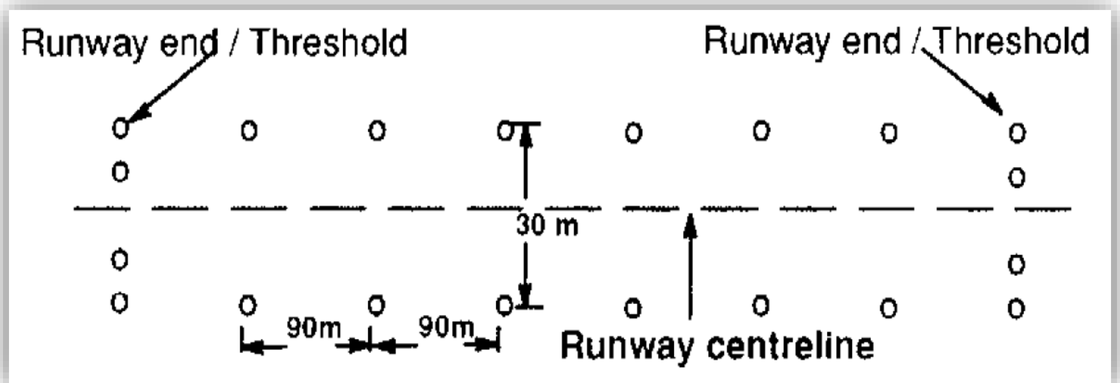
9.6.5.1 Landing on an Existing Strip

Where a fixed wing field landing is required (e.g. Aeromedical):

- Take radio and mobile phone to allow communication between the site and the aircraft to ensure airstrip is clear of all livestock and wild animals (etc.)
- Check condition of airstrip for potholes or large ruts. If unsure of hardness, drive 4WD vehicle through the middle of the runway and if wheels sink, advise the pilot to direct aircraft to alternative strip
- Where available set up 'White Runway Cones' to mark the perimeter of the run way
- When airstrip is clear and in good condition, advise pilot that the airstrip is ready to receive the aircraft
- Maintain watch to ensure the airstrip remains clear and be prepared to advise the aircraft of wind direction and condition of airstrip if requested.

9.6.5.2 Landing at Night

Personnel will fly to and from rostered work in the Northern Territory arriving at and departing from the airports at Alice Springs and Darwin. The closest airstrips to operations during this campaign are located at Erldunda and Tanumbirini Station.



Airstrip Landing Lights

9.6.5.3 Landing on the Road

Locate a road that is:

- Preferably sealed, free of undulations, ruts or potholes
- 2,000 meters of straight road
- At least 15 meters wide.
- Remove all guide posts, road signs or obstacles above ground level upon notification of landing location by the RFDS pilot
- Guard both ends of the 2,000 meters to stop vehicles from entering.

9.6.5.4 Fixed Wing Aircraft Safety (e.g. RFDS)

The following principles apply in relation to fixed wing aircraft safety.

- Do not approach the aircraft until advised to do so by the pilot. This advice will be given when the propeller(s) are stationary, the external lights are off, the cabin door is open and rotating beacon is switched off
- Do not walk under the wing
- Do not run
- Do not smoke near the aircraft or at the landing area
- Where a vehicle is required to drive to the aircraft, this will be done under the direction of the pilot under the following conditions:
    - Vehicle speed must not exceed 10kph
    - Vehicle must stop at least a wings length away from the aircraft
    - Do not reverse the vehicle towards the Aircraft.

10 TRAINING AND EXERCISES

Personnel shall be trained to effectively fulfil their roles and responsibilities.

Training against this Plan may be in the form of class room review, simulated emergencies, practical drills, desktop exercises, resources and equipment checks, or other exercises designed to systematically include personnel likely to be involved.

Emergency exercises shall be conducted to:

- verify that the emergency plans provide adequate coverage across the range of incident categories;
- test the effectiveness of this Plan;
- validate the competency and response times of key emergency response personnel, including knowledge of individual roles and responsibilities;
- assess the capability to respond to an emergency;
- reinforce prior training;
- identify opportunities for improvement to this Plan;
- provide confidence to participants around emergency decision-making, and
- verify adequacy of communication channels, both internally and externally.

This Plan will also be deemed to be exercised if an actual emergency occurs and components of the plan are activated.

Any non-conformance and improvements of the procedures outlined in the Plan shall be identified and action taken to remedy.

Emergency Response Drills/Exercises will be conducted in accordance with the requirements of Santos SMS-MS11-ST1 – Emergency and Crisis Management

In addition, exercises will be conducted in accordance with Contractor EHS System requirements, and further to that there will be an annual exercise that should incorporate as many aspects of this Plan as practicable.

Exercises may be internally or externally facilitated.

Records of exercises are kept in the Emergency Response module of Santos EHS Toolbox.

11 APPENDICES

Appendix A – Contact Numbers

Santos			
Name	**Number**	**Name**	**Number**
Steve Roberts NT Project Lead (Adelaide)	Wk. – (08) 8116 5249 M – 0400 282 805	**George Nairn / Justin Horan** NT **Project** Drilling Superintendents (B2B)	Wk. – (08) 8116 5045 George – 0438 799 687 Justin – 0478 653 632
Jessica Wrigley D&C Project Engineer (Adelaide)	Wk. – (08) 8116 7560 M – 0401 080 168	**Nearest Local Santos Base:** Adelaide D&C., 24hr. coverage (Steve Roberts)	0400 282 805
Onshore D&C Operations Risk (Moomba)	S'visor (08) 8678 4425 or Coach (08) 8678 4426	**Santos D&C Materials Co-ordinator Moomba** Alternate 24hr Contact:	(08) 8678 4199 0417739895

Rig / Operations		Company phone numbers	
Santos OCR **NT Satellite Phone in Blue**	08 8116 6100 - Office TBA	**Santos Onshore D&C Operations Risk Coach**	TBA
Ensign 965 Rig Manager	08 8287 8116 - Office		
Ensign 965 Camp site	TBA - Office TBA – Kitchen (Main #)		

Northern Territory Government			
Dept. Primary Industry & Resources (Petroleum)	**General** (08) 8999 7348	**Emergency** (08) 8999 6350 **AH** 1300 935 250	

OTHER		
Hospitals & Medical Services		
Royal Darwin Hospital 105 Rocklands Drive, Tiwi NT 0810	(08) 8922 8888	**Major Hospital** - is the largest teaching hospital in the Northern Territory & is also recognised as Australia's National Critical Care & Trauma Response Centre.
Katherine Hospital –Lot 1939 Gorge Rd, Katherine NT 0850	(08) 8973 9211	**District Hospital** - an accredited 60-bed non-specialist medical, diagnostic & treatment facility, catering for the needs of the population of Katherine and District.
St Johns Katherine Ambulance – Lot 3159 Chardon St, Katherine South NT 0850	(08) 8972 8500	
St Johns Alice Springs Ambulance – Telegraph Tce., Alice Springs	(08) 8959 6600	
Aeromedical Services		
Care Flight	(08) 8928 9777 **24hr Emergency** 1300 655 855	CareFlight has Agusta AW 139 & Kawasaki BK117-B2 helicopters, Beechjet 400 & B200 King Air aircraft based in the NT, available 24 hours a day.
RFDS	**24hr Emergency** NT – 1800 733 768 SA – 1800 733 772 **HF Radio** – 4010kHz, 6890Hz or 8165kHz **Satellite** – (08) 8648 9555	The RFDS has 4 different planes that are used for operations. WA & NT - Hawker 800XP WA, SA & NT - Pilatus PC-12

Police			
Emergency 000 24hr Assistance 131 444			
Alice Springs Police	(08) 8951 8823	**Katherine Police (0830hrs – 1600hrs Mon-Fri only)**. Address: Stuart Hwy, Katherine East NT 0850	(08) 8973 8000
Fire Services			
N T Fire & Rescue AH – (08) 8922 1555			
Alice Springs Fire Station	(08) 8951 6688	**Katherine Fire Station**	(08) 8973 8014
General			
BP Service Station Katherine 6 Katherine Tce, Katherine NT 0850	(08) 8971 9924 (08) 8971 9955	**Erldunda Roadhouse** Stuart Hwy & Lasseter Hwy, Erldunda NT 0872	(08) 8956 0984
BP Service Station Adelaide River - NT 106 Stuart Hwy, Adelaide River NT 0846	(08) 8976 7047	**Hi-way Inn Daly Waters Petrol Station** Cnr Stuart & Carpentaria Hwys Daly Waters NT 0852	(08) 8975 9925
United Petroleum Service Station 44 Moule St, Pine Creek NT 0847	(08) 8976 1217	**United Petrol Station** 13 Roper Tce, Mataranka NT 0852	(08) 8975 4761
United Service Station 68 Palm Circuit, Ross (Alice Springs) NT 0873	(08) 8952 1638	**Coles Express Service Station** Lilbili St & Dalgety Road, Alice Springs NT 0870	(08) 8952 9622

Appendix B – Emergency Situation Checklists

Checklists have been developed to assist with responding to a variety of emergency situations. The checklists are detailed in the following pages and can be found on the Cooper D&C SharePoint site at:

http://teams.santos.com/sites/DC/EADC/DCEHS/Emergency_Response/Forms/Public_View.aspx?InitialTabId=Ribbon%2EDocument&VisibilityContext=WSSTabPersistence

1.1 Bushfire Procedure Activity Checklist

Initial site activity by all personnel

- If you start a fire and can put it out with a beater or fire extinguisher do so. If the fire is larger than a few square metres, flame height greater than 0.3m, or the fire is gaining on your attempt to extinguish it, stop and ensure the fire is immediately reported.
- If you observe a fire or smoke, notify the local Fire & Rescue Service immediately via 000 or phone number contained in the contact numbers listed in this plan, providing as much information on the fire as possible:
  - time of reporting the fire
  - location of the fire and any distinguishing landmarks
  - approximate size of the fire and/or height of the flames
  - the speed that it is moving and in what direction
  - whether it is contained or likely to spread
  - the approximate wind speed and direction
  - the nature of the vegetation and terrain the fire is in
  - the nature of the vegetation and terrain where it might spread to
  - any sites in close proximity to the fire
- If unsafe to remain in your location due to fire heading your way, go to the nearest camp, town or large cleared area.
- If you are unable to get to any of the above, take actions to prepare your vehicle for a potential burn-over.

On Scene Commander

- Ensure the following pertinent information is obtained from the scene and forwarded to the IOC
  - Potential human threat, any injuries and/or fatalities.
  - Local weather conditions, wind direction and speed
  - Equipment, infrastructure threat and damage
  - Ownership of land, equipment, infrastructure at threat
  - Environmental threat and damage.
  - Available resources
  - What caused the fire
  - Whose responsibility is the fire
  - What actions are currently being undertaken at the scene
- Ensure the safety of all operators.
- Provide assistance with plotting of the fire from the ground if requested.
- Assist with identification of key facilities in the predicted fire path. Consider associated dynamic risks i.e. gas venting and include in strategy development.
- Stop unauthorised entry into the area.

- Supply appropriate and timely situation reports to Emergency Response Coordinator.
- Consider requirement for any isolations and task resources to carry out same if deemed necessary.

IMT Operations Officer

- Confirm that Emergency Services have been notified of event.
- Obtain pertinent information from the scene
  - Potential human threat, injuries and/or fatalities.
  - Local weather conditions, wind direction and speed
  - Equipment, infrastructure threat and damage
  - Ownership of land, equipment, infrastructure at threat
  - Environmental threat and damage.
  - Available resources
  - What caused the fire
  - Whose responsibility is the fire
  - What actions are currently being undertaken at the scene
- Assist with formulation of a management plan to deal with the emergency and deploy resources as necessary
- Arrange for fire area to be plotted and mapped to aid management and reporting requirements
- Maintain an operations log of initial planning discussions and activities
- Assist with formulation of emergency management plan with assembled IMT.
- Ensure fire plot is correctly overlaid on to Santos GIS mapping and disseminate as required.
- Deploy other field services resources as necessary

IMT Leader

- Obtain pertinent information from the scene
  - Potential human threat, injuries and/or fatalities.
  - Weather report/forecast wind direction and speed
  - Equipment, infrastructure threat and damage
  - Ownership of Land, Equipment, infrastructure at threat
  - Environmental threat and damage.
  - Available resources
  - What caused the fire
  - Whose responsibility is the fire
- What actions are currently being undertaken at the scene
- Ensure medical care is available for any injured persons
- Ensure the necessary notifications are carried out
  - Santos management as per normal IMTL responsibilities
  - Northern Territory Government Departments Primary Industries & Resources (DPIR)
  - Northern Territory Fire & Rescue Authority
  - Land owner
- Develop and implement overall action plan in consultation with IMT
- Provide resources to On-Scene Commander / Operations Officer as required
- Supply appropriate and timely situation reports to management
- Manage and maintain costs of emergency

1.2 Evacuation Procedure Activity Checklist

All Personnel

- On hearing an alarm or receiving verbal instruction, evacuate area on foot
- Go to Muster Point, stay until directed by On-Scene Commander/Muster Warden
- If the Primary Muster Point is unsuitable (e.g. due to smoke/wind direction etc.) relocate to Secondary Muster Point as nominated by the On-Scene Commander/Muster Warden
- If located in a remote area (that is not affected by emergency), contact your Supervisor by radio/phone, notify them of your location and stay there
- Personnel unfamiliar with site when an evacuation is triggered, must follow the Muster Warden's directions to the Muster Point.
- Take all escorted visitors to Muster Point
- Provide First Aid to any injured persons if qualified to do so
- Remain at Muster Point until instructed further by the Muster Warden or On-Scene Commander.

On Scene Commander

- Determine level of evacuation necessary in response to the emergency (and initiate alarms as appropriate)
    - Confer with D&C Superintendent (IMT Operations Officer)
    - Audible alarms, broadcast on radio, word of mouth
- Arrange for the safe shutdown of equipment / plant in the affected area (if possible) if personnel are not endangered in the process
- Advise the IMT Operations Officer of emergency and request support if required
- Review suitability of the primary Muster Point. Determine an alternate location if necessary
- Confirm unaccounted personnel with Muster Point Warden
- Request the IMC to assist with resources for rescue or evacuation as necessary
- Arrange searches for any personnel reported missing (coordinate with IMC and/or Muster Warden)
- Instruct the Muster Warden in consultation with the IMT Operations Officer regarding further proceedings (i.e. whether personnel should leave the site and where personnel should be relocated)
- Stay in communication with all Muster Points and keep the IMT Operations Officer up to date with emergency developments (for communication to evacuees)
- Following conclusion of the emergency, give the Muster Warden the "All Clear" for evacuees to leave the Muster Point and advise them of any restrictions on their movements (e.g. restricted areas for site personnel).

Muster Warden

- Ensure that the affected site is clear (that all personnel have evacuated)
- Check muster board for tags and conduct head count
- Pass on emergency status/developments to the evacuees
- Do not allow personnel to leave Muster Point without permission from the On-Scene Commander

- Maintain log of events including movements in and out of the Muster Point
- Assist with further evacuation of personnel/relocation of evacuees as required.

1.3 Injury / Fatality Procedure Activity Checklist

Person at the Emergency Scene

- Raise the alarm and notify On Scene Commander, report the nature, location and extent of emergency.
- Evaluate the emergency area and take actions to make it safe (do not take unnecessary risks)
- Provide first aid to injured persons (if qualified to do so) – only move patient if their injuries are minor or they are in IMMEDIATE danger
- Cordon off the area involved to preserve the scene and the integrity of any subsequent investigation
- Stay at emergency scene with injured person until help arrives (if safe to do so).

On Scene Commander

- Proceed to emergency scene and assess the situation (hazard assessment/response options)
- Ensure D&C Superintendent (IMT Operations Officer) has been notified of the emergency
- Cordon off scene and exclude all non-essential personnel from area
- If injury is minor and patient can be moved, transfer patient to first aid station/medical centre
- Arrange for the safe shutdown of equipment/plant in the affected area if it is presenting a hazard to the injured personnel/their rescuers
- Notify IMT Operations Officer of required rescue/transport/on scene medical assistance and provide a SITREP (details/location/conditions)
- Take actions as appropriate to make the incident scene safe
- Develop ongoing response strategy in consultation with IMC
- If IMC is activated, provide regular updates/briefings to allow appropriate responses to emergency developments
- Request assistance from IMC for treatment/evacuation of injured personnel (e.g. to medical centre) and that the destination facility can treat injuries (e.g. has appropriately skilled doctors/access to machines/drugs/antidotes)
- Do not move fatalities without Police approval
- In the event of a serious injury/fatality, refer all notification requirements to the IOC (DO NOT undertake notification of next of kin, other site employees, regulators media, public, external parties etc.)
- Secure the scene.
- Assist with investigation and review of the procedures/actions taken.

1.4 Fire / Explosion Procedure Activity Checklist

Person at the Emergency Scene

- Remove yourself and others from danger (DO NOT place yourself in unnecessary danger). Stop all work, extinguish any possible ignition sources and evacuate the area on foot.
- Activate the Emergency Shutdown if applicable
- Raise the alarm and report the nature, location, extent of emergency, wind direction and product if known – (Raise the alarm and notify On Scene Commander, report the nature, location and extent of emergency)
- Contain the fire with correct extinguisher if trained and it is safe to do so
- For a vehicle fire; stop the vehicle and if possible, use a hand-held powder extinguisher to extinguish fire (red with white band)
- Evacuate the area if fire spreads/escalates beyond control (remember your safety is paramount). Shut down equipment/plant if safe to do so
- Go to Muster Point and stay until directed by Muster Warden or On-Scene Commander
- When evacuating from a fire, DO NOT GO DOWNWIND OF THE SOURCE, AS EXPOSURE TO THE SMOKE/FUMES MAY BE LIFE THREATENING
- Do not enter smoke filled buildings and avoid passing through smoke plumes enroute to Muster Point
- Close doors/windows etc. as you evacuate buildings to help contain the fire
- Provide First Aid to any injured persons if qualified and safe to do so.

On Scene Commander

- Initiate alarms to warn site personnel – audible alarms, broadcast on radio, word of mouth
- Mobilise appropriate firefighting resources if safe to do so
- Proceed to scene and assess the situation (hazard assessment/response options). Consider the following:
- Combustible materials (flammable stores, toxic fumes/gas, vehicles, buildings etc.)
- Structures affected by the fire (heat damage to buildings/steelwork)
- Arrange for the safe shutdown of equipment/plant in the affected area
- Ensure medical aid is provided to injured personnel
- Notify the IMT Operations Officer and provide a SITREP (emergency details/location/conditions)
- If primary Emergency Muster Point is downwind of fire/affected by products of combustion from fire, determine an acceptable alternate Muster Point (in consultation with the Muster Warden)
- Identify any chemicals that may be involved in the fire and the risks associated with them (e.g. toxic products of combustion, handling/exposure) – communicate to IMT Operations Officer and attending Emergency Services. Obtain the relevant Chemical Manifests and/or SDSs as required
- Initiate alarms to warn site personnel – audible alarms, broadcast on radio, word of mouth

• Identify possible escalation targets for fire (nearby storage areas, vehicles) and arrange for mitigation actions to protect them in consultation with the Rig Manager (Field Response Team Leader (FRTL))	
• Provide regular SITREPS to the IMT Operations Officer and develop ongoing response strategy in consultation.	
• If fire/explosion escalates or creates secondary hazards to personnel, consider further/more extensive evacuations (or relocation of evacuated personnel)	
• For bushfire – consider safety of site and possibility of smoke affecting other services/properties/personnel	
• For a significant bushfire consult with the IMT Operations Officer /FRT regarding the use of fire breaks at site	
• Assist with/request further evacuation of personnel as required	
• Assist in investigating the emergency and reviewing the procedures/actions taken.	

1.5 Chemical Spill / Gas Release Procedure Activity Checklist

Person at the Emergency Scene

- Remove yourself and others from danger (DO NOT place yourself in unnecessary danger)
- Raise the alarm and notify On Scene Commander, report the nature, location and extent of emergency
- Evacuate areas that may be affected by the spill either directly or through exposure to fumes (remember your safety is paramount)
- Immediately try to locate the source of the spill, remaining up wind
- When evacuating a chemical spill/gas release, DO NOT GO DOWNHILL/DOWNWIND OF THE SOURCE, AS EXPOSURE TO THE FUMES MAY BE LIFE THREATENING
- If release is from a storage facility, isolate/contain the release (if it is safe to do so) by closing valves, switching off pumps, blocking drains, establishing temporary bunds, use of spill kits, contacting control room etc.
- Disperse escaping flammable gas vapours at the source using water spray if safe to do so
- Identify and isolate any potential sources of ignition
- Go to Muster Point, stay until directed by the Muster Warden or On-Scene Commander
- Provide First Aid to any injured persons if qualified to do so
- Ensure that any contaminated personnel utilise emergency showers and eye washes
- Safely dispose of any contaminated clothing.

On Scene Commander

- Initiate alarms to warn site personnel – audible alarms, broadcast on radio, word of mouth
- Ensure site of emergency is evacuated to a safe distance; evacuate all areas that:
    - Are directly affected by the release (impinged / engulfed)
    - May be indirectly affected (e.g. exposure to toxic fumes / vapour cloud, access restrictions
- Arrange for the safe shutdown of equipment/plant in the affected area
- Ensure that emergency services have been contacted
- Notify the IMT Operations Officer and provide a detailed SITREP of the situation (details, site location/conditions)
- Identify released materials and source appropriate chemical manifests and/or SDSs; make these available for response personnel as necessary
- In consultation with the Muster Warden, determine the suitability of the Primary Muster Point (is it affected by/downwind of release); determine alternate Muster Point as required
- For an offsite spill/release, ensure that the IMT Operations Officer has all information required to carry out appropriate notification of government departments, Police etc.
- Relay all environmental information to the IMT Operations Officer and ensure that appropriate environmental/governmental agencies are notified

• Determine containment/decontamination requirements (in consultation with FRT or specialists – onsite or offsite) and source equipment from offsite as required – confer with IMT.	
• Continue to provide SITREPS to the IMT Operations Officer and FRT - develop ongoing response strategy in consultation with them	
• When developing response strategies, consider: ◦ Physical response constraints (weather, wind direction/strength, release location) ◦ Review available chemical manifests and/or SDSs ◦ PPE/response equipment availability ◦ Exposures of site personnel (injuries/trapped personnel)	
• Ensure that appropriate toxic/chemical exposure monitoring is conducted during response to limit responder's exposure to within acceptable levels (refer to relevant chemical manifests and/or SDSs)	
• If spill/release escalates or creates secondary hazards to personnel (e.g. escalation, exposure to spill/release), consider further/more extensive evacuations (or relocation of evacuated personnel)	
• Arrange for barricading of affected area until remediation is complete/atmosphere is clear	
• When considering the impacts of the release, take into the account any potential for contamination of site water supplies – provide alternate drinking water supply if required	
• Try to minimise the impact of the spill by implementing the three C's rule: ◦ CEASE flow of release into the surrounding area ◦ CONTAIN the spillage ◦ CLEAN-UP spill	
• Review the need for any off-site expertise or equipment to control/contain the spill/release and communicate requirements to the IMT Operations Officer	
• Assist with investigation and review of the procedures/actions taken.	

1.6 Electric Shock Procedure Activity Checklist

Person at the Emergency Scene

- Remove yourself and others from danger (DO NOT place yourself in unnecessary danger)
- Raise the alarm and notify On Scene Commander, report the nature, location and extent of emergency
- Evaluate the situation and take actions to make it safe (do not take unnecessary risks) such as;
  - Isolate the source of the electricity
  - If source cannot be isolated, use a non-conductive lever to move the casualty from the source
- DO NOT TOUCH any injured persons until area has been made safe
- Provide first aid to any injured persons (if qualified to do so) – only move them if the injuries are minor or they are in IMMEDIATE danger
- Stay at scene with injured person until help arrive (if safe to do so)

On Scene Commander

- Ensure that Emergency Services have been notified
- Cordon off scene and exclude all non-essential personnel from area
- Confirm that electricity to the scene has been isolated/controlled prior to commencing response
- Arrange for the safe shutdown of equipment/plant in the affected area if it is presenting a hazard to the injured personnel/their rescuers
- Ensure that any injured personnel are provided with appropriate first aid and are monitored until help arrives
- Notify the IMT Operations Officer and provide a detailed SITREP of the situation (details, site location/conditions)
- Consult with a qualified electrician (either onsite or via the IMC) for advice on response related electrical matters
- When conducting electrical isolation of a process/area, consider the potential for;
  - Detrimental effects on safety systems i.e. will the isolation disable a critical control of personnel safety?
  - Loss of positive control of equipment
  - Loss of amenities (e.g. lighting, mains power supply)
- Continue to provide SITREPS to the IMT Operations Officer- develop ongoing response strategy in consultation with them
- Request support from the IMC for treatment/evacuation of injured/deceased personnel (e.g. to medical centre)
- In the event of a serious injury/fatality, refer all notification requirements to the IMT Operations Officer (DO NOT undertake notification of next of kin, other site employees, regulators, media, public, external parties etc.)
- Assist with investigation and review of the procedures/actions taken.

1.7 Confined Space Procedure Activity Checklist

Person at the Emergency Scene

- Remove yourself and others from danger (DO NOT place yourself in unnecessary danger)
- Raise the alarm and notify On Scene Commander, report the nature, location and extent of emergency
- Refer to the CSE Emergency Plan developed from the CSE Risk Assessment
- DO NOT ENTER (and prevent others from entering) confined space until the atmosphere has been tested and declared safe
- ONLY when atmosphere is declared safe (LELs O2) - Provide first aid to injured persons (if qualified to do so) – only move patient if their injuries are minor or they are in IMMEDIATE danger
- Stay at scene with injured person until help arrives (if safe to do so).

On Scene Commander

- Determine details of confined space activity and any related hazards (e.g. contaminated/flammable atmosphere, electrical, gravity) – refer to Confined Space Entry Permits
- Proceed to scene and assess the situation (hazard assessment/response options), consider:
  - Type of activity being conducted in confined space (e.g. hot work, atmospheric testing)
  - The need to forcibly ventilate the confined space (or use BA gear to work in it)
  - The need for continual monitoring of the atmosphere (for breathability, flammability)
- Determine the need for external assistance
- Cordon off scene and exclude all non-essential personnel from area
- Ensure that the confined space has been tested/made safe prior to commencing response
- Notify the IMT Operations Officer and provide a detailed SITREP of the situation (details, site location/conditions)
- Ensure that any injured personnel are provided with appropriate first aid and are monitored until help arrives
- Continue to provide SITREPS to the IMT Operations Officer
- Request support from the IMC for treatment/evacuation of injured personnel (e.g. to medical centre)
- Assist with investigation and review of the procedures/actions taken.

1.8 Vehicle Incident Procedure Activity Checklist

Person at the Emergency Scene

- Remove yourself and others from danger (DO NOT place yourself in unnecessary danger).
- Raise the alarm and notify On Scene Commander &/or Emergency Services (phone '000'), report the nature, location and extent of emergency, exact location of incident and distance/direction from nearest major site or land mark. Provide GPS co-ordinates if possible (confirm co-ordinate format)
  - Number of vehicles involved
  - Number of persons injured
  - Nature of injuries
  - Number of persons possibly trapped in vehicle
  - Any hazardous materials or dangerous goods involved
  - Any signs of smoke or fire
- Position other vehicles in a fend-off position with hazard lights activated to protect scene from oncoming traffic.
  NOTE: If vehicle is in contact with power lines stay clear and tell occupants to stay in vehicle
- Provide First Aid to any injured persons if qualified to do so
- Do not try to remove casualties from vehicle unless other dangers are present which may endanger life it they were not removed
- Make vehicle safe, including;
  - Lower hydraulic equipment (e.g. raised buckets/lifting platforms etc.)
  - Switch off vehicle ignition, isolate power
  - Cover any split petrol/diesel with sand

On Scene Commander

- Proceed to scene, assess the situation and render assistance to vehicle occupants (hazard assessment/response options), including consideration of:
  - Danger from oncoming traffic
  - Ensure that vehicle is stable
  - Dangerous goods carried by the vehicle (e.g. fuel, explosives)
  - Location hazards (e.g. presence of electricity, potential for escalation)
  - Damage to buildings/equipment from incident (e.g. structural damage
- If safe to do so, extinguish any fires - mitigate against any fires beginning
- Control any Chemical hazards (refer Chemical Spill/Gas release procedure)
- Arrange for the safe shutdown of equipment/plant in the affected area if it is presenting a hazard to the injured personnel/their rescuers
- Ensure the trapped / injured are provided with appropriate first aid treatment and monitored until help arrives
- Notify the IMT Operations Officer; provide a detailed SITREP of the situation (details, site location / conditions)
- Determine the need for any other external assistance and advise IMC
- Continue to provide SITREPS to the IMT Operations Officer – develop ongoing response strategy in consultation with them
- Cordon off scene and exclude all non-essential personnel from area

NOTE: Consider requirement for establishment of a landing zone for rotary wing aircraft that may be used for medical evacuation of injured parties (refer Helicopter Support section)

- Assist with investigation and review of the procedures/actions taken

1.9 Aircraft Incident Procedure Activity Checklist

Person at the Emergency Scene

- Remove yourself and others from danger (DO NOT place yourself in unnecessary danger) consider high risk associated with spinning rotors, propellers and/or turbines
- Raise the alarm and notify On Scene Commander &/or Emergency Services (phone '000'), report the nature, location and extent of emergency, exact location of incident and distance/direction from nearest major site or land mark. Provide GPS co-ordinates if possible (confirm co-ordinate format) and provide the following information:
    - Exact location of accident and distance/direction from nearest major site or land mark. Provide GPS co-ordinates if possible (confirm co-ordinate format)
    - Number of persons injured
    - Nature of injuries
    - Number of persons possibly trapped in vehicle
    - Any hazardous materials or dangerous goods involved
    - Any signs of smoke or fire
- Provide First Aid to any injured persons if qualified to do so
- Cover any spilt aviation fuel with sand or firefighting foam if available
- Do not try to remove casualties from aircraft unless other dangers are present which may endanger life it they were not removed.

On Scene Commander

- Proceed to scene, assess the situation and render assistance to aircraft occupants (hazard assessment/response options), including consideration of;
    - Dangerous goods carried by the aircraft (e.g. fuel, explosives)
    - Location hazards (e.g. presence of electricity, potential for escalation)
    - Damage to buildings/equipment from accident (e.g. structural damage)
- Ensure Moomba Communications have been notified and have all relevant information
- Assist with the extrication of trapped personnel from aircraft, if safe to do so – injuries permitting
- Ensure the trapped/injured are provided with appropriate first aid treatment and monitored until help arrives
- If safe to do so, extinguish any fires, take necessary steps to prevent any new ignition
- Confirm number of personnel/visitors on board
- Notify the IMT Operations Officer and provide a detailed SITREP of the situation (details, site location/conditions)
- Continue to provide SITREPS to the IMC to develop ongoing response strategy (e.g. further resource requirements/CASA/Air Services Australia)
- Request support from the IMC for treatment / evacuation of injured personnel (e.g. to medical centre/temporary Casualty Clearing Area
- Cordon off scene and exclude all non-essential personnel from the area
- Assist with investigation and review of the procedures/actions taken

1.10 Missing Person / Vehicle Procedure Activity Checklist

Identification

Emergency response may be initiated by Journey Manager; 30 minutes after person fails to make contact or comply to normal schedule routines

Uncertainty Phase: - 30 minutes after person fails to make contact or comply to normal schedule/routine

On Scene Commander

- Attempt to contact the missing person via phone/radio or by calling their destination to ascertain if there was anything that prevented the person from meeting their schedule
- Refer to Journey Management details; confirm departure time, number of personnel on board, intended route, destination ETA, vehicle details and last communication received
- Initiate continuous attempts to contact vehicle using sat phone, local phones or VHF radio – maintain efforts
- Ensure dedicated personnel monitor radio and phone continuously but specifically every hour/half hour for any distress call
- Contact any local route checkpoints for last known contact, maintain liaison.
- Contact the driver's supervisor / team leader to establish if the driver / persons are unaccounted for
- Check Rig muster board
- Check missing person(s) room at camp, office, lunch room and ablutions area
- Ensure all other relevant site personnel are informed
- Confirm "last seen" details with any witness(s)
- Notify the IMT Operations Officer and provide a detailed SITREP of the situation (details, site / location / conditions)

IMT Leader

- Active the IMC – allocate tasks to record Search & Rescue (SAR) actions taken / contacts made
- Calculate theoretical fuel range of missing vehicle, use range as search radius from point of last known contact; dissect radius into search grids for controlled SAR activity
- Specialist access information may be required if vehicle was being used for off-road scouting or inspections
- Utilise large scale maps for monitoring/organising of search areas/parties (plot missing persons last known activities/locations)
- Make reproductions of area map for use by search teams
- Dispatch search vehicle, helicopter etc. (GPS equipped if possible) from closest location to initiate preliminary search along last known route of missing person/vehicle
- Ensure that only experienced personnel are mobilised and that at least 2 people are present in the vehicle (search vehicle journey management procedures must be in place)
- Consider the suspension of current work program pending SAR activities

- Alert any other facilities/operations/vehicles in the area
- Determine further SAR resources and place on short notice standby.

Distress Phase: - 1.5 hours after initiation of 'Uncertainty Phase'

Incident Management Centre

- Maintain liaison with Journey Management, update them regularly of any developments
- Dispatch further search vehicle(s) (GPS equipped if possible) to cover specific search grids as determined by preliminary search
- Instruct search personnel to look for signals on the hr. / ½ hr. (e.g. smoke, heliograph, flare)
- Maintain communication with SAR vehicle(s) (VHF, sat phone, local phones etc.)
- IMTL to alert authorities (e.g. Police) and request participation in SAR as appropriate
- IMTL to mobilise other external SAR resources (e.g. aircraft/Police) as required to carry out effective SAR
- Consider calling off search at night or if conditions become hazardous to searchers
- Consider escalation of SAR operations the longer the vehicle is missing
- IMTL to handover SAR control to Police/other authorities) if Initial search by Santos resources fails to locate missing persons / vehicle
- When planning the SAR, ensure that the following points are addressed:
    - SAR is led by a suitably trained/experienced person
    - Suitable vehicles and equipment (rescue/recovery gear, first aid kit, survival gear) are used in SAR
    - Adequate clothing, water and food is provided for both the searchers and the survivors
    - Clear communications rules/procedures are developed, and reliable communications equipment used
    - Suitable maps and locating equipment (e.g. GPS) are supplied to all searchers

Incident Management Teal Leader

- Notify IMT and provide updates on SAR progress at regular intervals
- Oversee and maintain communications with SAR teams
- Ensure ongoing support is maintained for the provision of fuel, meals, supplies and relief of SAR team members as required
- Ensure that Emergency Services have been notified and are on alert (for prompt response following discovery of missing person/people)
- Following location of the missing vehicle, ensure the provision of first aid or medical treatment to the occupants and/or transport to hospital
- Inform the IMT & SAR team members when the emergency is over
- Conduct a debrief with all involved personnel following SAR conclusion
- Assist in the investigation and review of the procedures/actions taken.

1.11 Helicopter SAR Procedure Activity Checklist

Identification

Emergency Response may be initiated by Journey Manager; 20 minutes after person fails to make contact scheduled arrival

Uncertainty Phase: - 15 minutes after person fails to make scheduled report or arrival

Journey Manager

- Notify On-Scene Commander
- Continue attempts to establish communications with the aircraft
- Check scheduled destination contact for any available information
- If no contact is made with aircraft after 20 minutes after failure to make a scheduled report or arrival, declare Alert / Distress Phase
- Notify IMTL and provide a detailed SITREP (details, site location / conditions)

Alert / Distress Phase: - 20 minutes after failure to make a scheduled report or arrival

Incident Management Team Leader

- Activate the IMC – allocate tasks to record Search & Rescue (SAR) actions taken / contacts made
- Contact AusSAR (1800 815 257) and advise of missing aircraft and actions being taken
- Notify CMT DM and provide regular ongoing updates

Incident Management Centre

- Prepare for commencing further SAR activities in consultation with IMTL
- All other available aircraft to assist with search from point of last known contact;
- Realistic search area to be defined by rotary wing contract company operations officer and dissected into search grids for controlled SAR activity
- Utilise large scale maps for monitoring/organising of search areas/parties (plot missing aircraft' last known activities/locations)
- Make reproductions of area map for use by search teams
- Dispatch search vehicle, helicopter etc. (GPS equipped if possible) from closest location to initiate preliminary search near last known location of missing aircraft
- Ensure that only experienced personnel are mobilised and that at least 2 people are present in the vehicle (ensure search vehicle journey management procedures are in place)
- Consider the suspension of current work program pending SAR activities
- Consider utilising landowner assistance with searches in their relative areas
- Alert any other facilities/operations/vehicles in the area
- Determine further SAR resources and place on short notice standby
- Dispatch further search vehicle(s) (GPS equipped if possible) to cover specific search grids as determined by preliminary search
- Instruct search personnel to look for signals on the hr. / ½ hr. (e.g. smoke, heliograph, flare)
- Maintain communication with SAR vehicle(s) (VHF, sat phone, local phones etc.)

- IMC to alert authorities (e.g. Police) and request participation in SAR as appropriate
- IMC to mobilise other external SAR resources (e.g. aircraft/Police) as required to carry out effective SAR
- Consider calling off search at night or if conditions become hazardous to searchers
- Consider escalation of SAR operations the longer the vehicle is missing
- IMC to handover SAR control to Police/other authorities) if Initial search by Santos resources fails to locate missing Aircraft
- When planning the SAR, ensure that the following points are addressed:
  - SAR is led by a suitably trained/experienced person
  - Suitable vehicles and equipment (rescue/recovery gear, first aid kit, survival gear) are used in SAR
  - Adequate clothing, water and food is provided for both the searchers and the survivors
  - Clear communications rules/procedures are developed, and reliable communications equipment used
  - Suitable maps and locating equipment (e.g. GPS) are supplied to all searchers

IMT Leader

- Notify CMT DM and provide updates on SAR progress at regular intervals
- Oversee and maintain communications with SAR teams
- Ensure ongoing support is maintained for the provision of fuel, meals, supplies and relief of SAR team members as required
- Ensure that Emergency Services are on alert (for prompt response following discovery of missing person/people)
- Following location of the missing aircraft, ensure the provision of first aid or medical treatment to the occupants and/or transport to hospital
- Inform the IMT/SAR team members and Emergency Services when the emergency is over
- Conduct a debrief with all involved personnel following SAR conclusion
- Assist in the investigation and review of the procedures/actions taken.

1.12 Bomb / Terrorist Threat Procedure Activity Checklist

The Police are responsible for evaluation of any bomb, terrorist or security threat. For bomb threats, avoid the use of mobile phones or two-way radios until Police declare the site safe

Person Receiving Threat

- Notify the On-Scene Commander/Team Leader or Manager IMMEDIATELY upon receiving a threat or a suspicious object/package

For a written threat

- Keep all paper, envelopes etc. to preserve evidence

For an email threat

- Keep a copy of the email and do not close the PC

For a telephone threat

- Remain calm
- Listen closely to what the caller says
- Complete as much as possible of the Bomb / Threatening Call Record – appearing sympathetic and using a pleasant tone may extend the call
- When the call hangs up - DO NOT HANG UP YOUR PHONE (it may be possible to trace the call)
- Call for help as soon as possible USING ANOTHER PHONE or by attracting someone's attention visually

For a suspect object / package

- Do not touch the suspect object / package
- Evacuate the immediate area
- Notify the On-Scene Commander/Team Leader or Manager IMMEDIATELY

On-Scene Commander

- Notify Police of the threat and actions taken by telephoning '000'.
- Alert and coordinate with the Muster Warden a full site evacuation - initiate alarms to warn site personnel as appropriate
- Notify all site personnel of the situation and brief them of the details
- Establish Forward Command Post at least 300 meters from the scene
- Arrange for the safe shutdown of equipment/plant in the affected area as appropriate
- Notify the IMT Operations Officer
- When threat nominates a detonation time, stop the search 30 minutes prior to that time. Do not resume search until 30 minutes after nominated detonation time
- No radio transmissions should be made within 100 meters of the area
- If a suspicious package is located, record description and exact location but do not allow anyone to touch the package/item
- Evacuate all personnel to a safe distance
- Pass on package/item details to IMC and await further instructions
- Assist with investigation and review of the procedures/actions taken.

Santos

IMT Leader

- Instigate the activation of the IMC and carry out an emergency briefing (details, site location/conditions)
- Ensure all details have been passed on to OSC, relevant level 5 leader and/or contract company site leader
- Notify CMT DM and provide ongoing updates
- Call '000' – notify Police and brief them of the situation and any response actions underway
- Ensure required site evacuations have been undertaken as appropriate
- Implement Security Plan if deemed necessary
- Assist Police as and when required/requested (develop response strategy in conjunction with Police)
- Ensure all required resources are provided and maintained for FRT
- Terminate the emergency under instructions from the Police ONLY
- Ensure counselling is available to call receiver if required
- Assist with investigation and review of the procedures/actions taken.

1.13 Bomb / Terrorist Threat Record Form

Questions to Ask	Caller's Voice	
1. When is the bomb going to explode?	□ calm	□ nasal
	□ angry	□ stutter
2. Where is it right now?	□ excited	□ lisp
3. What does it look like?	□ slow	□ raspy
4. What kind of bomb is it?	□ rapid	□ deep
5. What will cause it to explode?	□ soft	□ ragged
	□ loud	□ clearing throat
6. Did you place the bomb?	□ laughter	□ deep breathing
7. Why?	□ crying	□ cracking
8. What is your name?	□ normal	□ slurred
	□ distinct	□ accent
9. What is your address	□ disguised	□ familiar
If the voice sounds familiar, who does it sound like?		

Exact Wording of the Threat	Background Sounds	
	□ street noises	□ animal noises
	□ crockery	□ clear
	□ voices	□ static
	□ PA system	□ local
	□ music	□ long distance
	□ house	□ motor noises
	□ phone booth	□ office equipment
	□ factory machinery	
	□ other	

Caller's Details		Threat Language	
Sex	male / female	□ irrational	□ incoherent
Race		□ foul	□ taped message
Age (in years)		□ well-spoken / educated	□ read by caller
Phone Received		**Your Details**	
On which number		Name	
Time	am / pm	Position	
Date		Telephone number	
Phone Reported		**Any Other Information**	
To			
Time	am / pm		
Date			

IMPORTANT – DO NOT HANG UP THE PHONE / OBTAIN AS MUCH INFORMATION AS POSSIBLE TO ASSIST WITH IDENTIFYING THE NATURE, LOCATION AND LIKELY SUPPORT RESOURCES REQUIRED FOR THE EMERGENCY
EXACT WORDING OF THREAT (Use Note Paper as Required)
QUESTIONS TO ASK:
Where is the bomb now?
When will the bomb explode?
What does the bomb look like?
What kind of bomb is it?
What will set the bomb off?
Did you place the bomb?
Why are you doing this?
What is your name?
What is your address?
Where are you now?
When will you call again?
What group do you represent?

COMMENTS (TICK AS REQUIRED)	YES	NO
Is the voice familiar to you?		
Did the caller appear to be familiar with your questions?		
Is the caller going to ring back with further information or demands?		
Final Information release to (identify what information was)		

DESCRIBE THE CALLER AS BEST YOU CAN (TICK AS REQUIRED)							
CALM		SLURRED		SOFT		DEEP BREATHING	
ANGRY		THROAT CLEARING		LOUD		CRACKING VOICE	
EXCITED		STUTTER		LAUGHTER		ACCENT	
SLOW		RAPID		CRYING		YELLING	
FAST		DISGUISED		NORMAL		THREATENING	

CALLER DESCRIPTION			BACKGROUND SOUNDS			
Male / Female	Age:	Race:	QUIET		MOTOR	
TELEPHONE (TICK)			VOICES		FACTORY	
Local	Long Distance	Sat Phone	STATIC		OFFICE	
Phone Box	Mobile		LOCAL		STREET NOISE	
OTHER DETAILS:			MUSIC		ANIMALS	
Time			CROCKERY		PA SYSTEM	
Duration (Min / Sec)			BOOTH		HOUSEHOLD	
Your Phone Number			AIRCRAFT		CHILDREN	

REMAIN CALM AND REPORT THE THREAT TO A SUPERIOR AND / OR THE AUTHORITIES IMMEDIATELY	THREAT DELIVERY (TICK)			
	FOUL		IRRATIONAL	
	TAPED		SCRIPTED	
	WELL SPOKEN		NERVOUS	

Appendix C – Site General Location

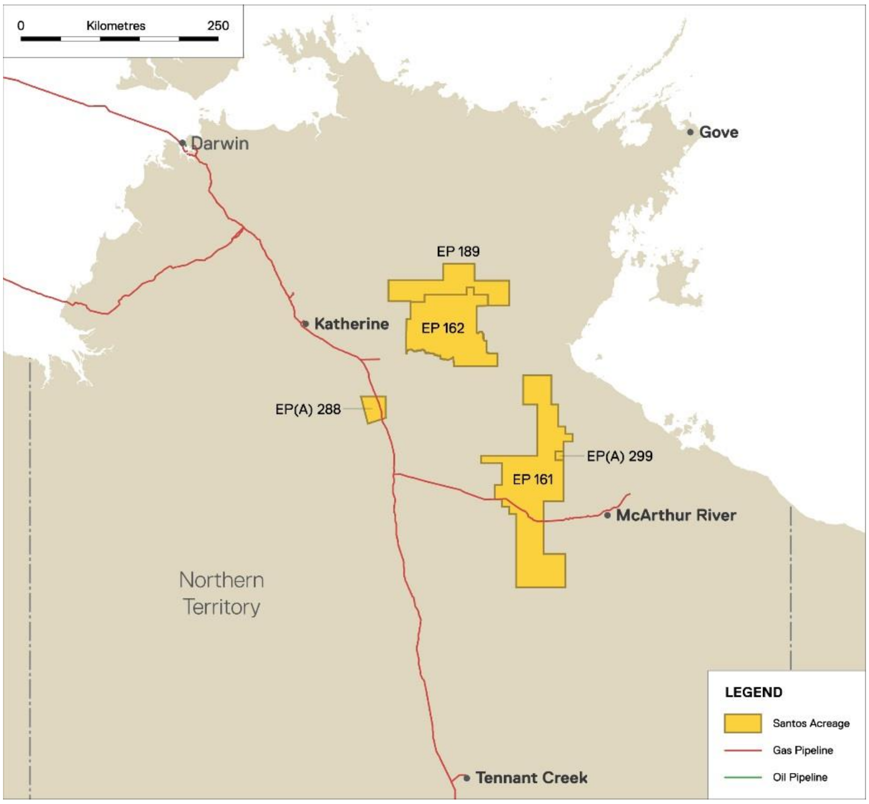


Figure 2A-1-1 McArthur Basin Project Area in Northern Territory

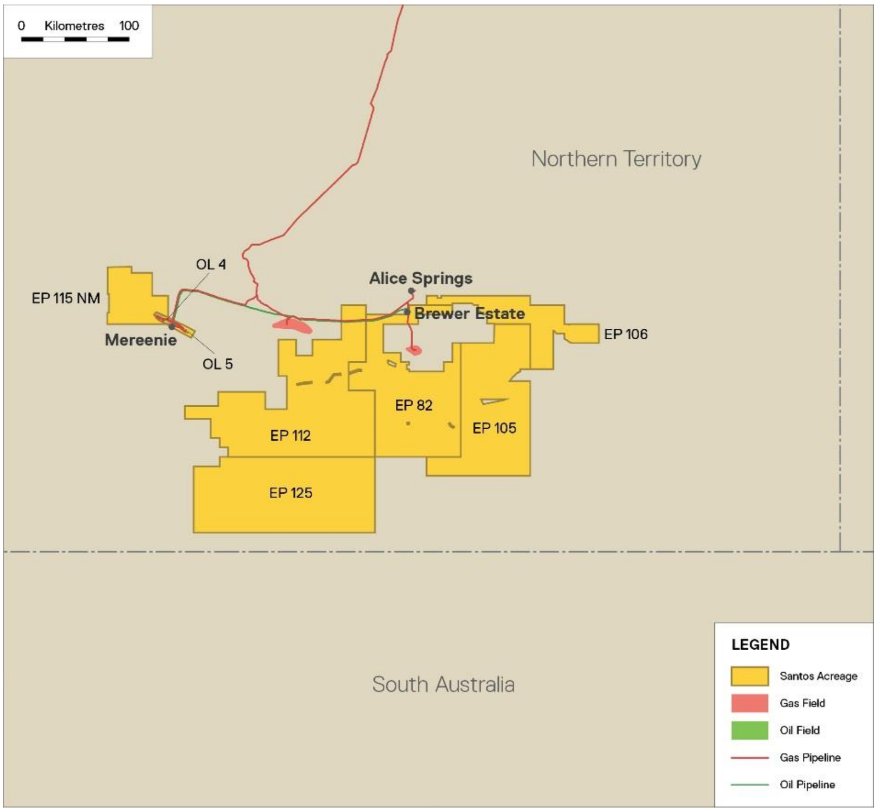


Figure 2A-1-2 Amadeus Basin Project Area in Northern Territory

Appendix D – Well Control Work Sheets

General Information		
Date:	Time:	Location:
Weather Condition:		

Operator Information	
Company	
Office Representative	Position
Phone Number	(email)
On-Site Representative	Position
Phone	(email)

Contractor Information	
Contractor	
Office Representative	Position
Phone	(email)
On-Site Representative	Position
Phone	(email)
Rig Name / Number	
Rig Type	

Well Information:			
Well Name:	Lease Name:		Field Name:
Well Type:		Well Location: GPS coordinates	
Wind Direction / Speed:			
Measured Depth:	True Vert. Depth:		Horizontal Section:
Relief Well Location Availability:		Closest Offset Well:	
Closest Town / City:		KM's From:	
Directions to Location:			
Closest Airport:		Runway Length:	
Closest hospital:		Closest police station:	

Blow-out Information:		
Blow-out Type:	Surface:	Underground Blow-out:
Blow-out Type:	Fire:	H2S:
	CO2:	Geothermal:
	Other:	
Product:	Gas:	Oil:
	Condensate:	Other:

Wellbore Information:					
Surface Casing					
Size:	Weigh:	Grade	Depth	LOT	SICP
Intermediate					
Size:	Weight:	Grade:	Depth	LOT	SICP
Long String					
Size:	Weigh:	Grade	Depth	LOT	SICP
Tieback Liner					
Size:	Weigh:	Grade	Depth	LOT	SICP
Production String					
Size:	Weigh:	Grade	Depth	LOT	SICP
Open Hole					
Size:	Weigh:	Grade	Depth	LOT	SICP
Tubular Data (Drilling):					

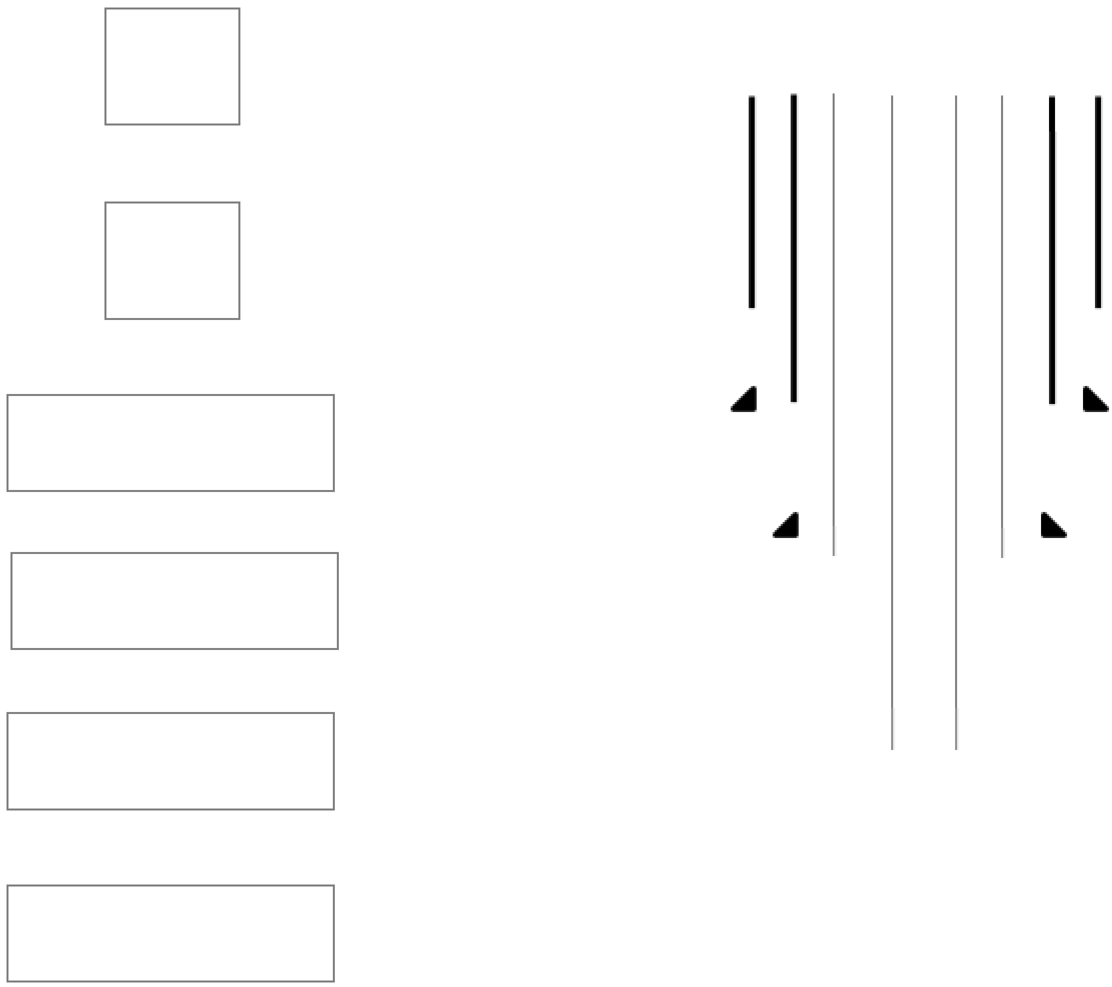
Drill Pipe 1	SIDPP				
Size:	Weight	Grade	Length	Joints	
Drill Pipe 2					
Size:	Weight	Grade	Length	Joints	
HW Drill Pipe					
Size:	Weight	Grade	Length	Joints	
Drill Collars					
Size:	Weight	OD	ID	Length	Joint
Monel	Size	Weight	OD	ID	Length
Mud Motor	Type	Size		Length	
Stabilizers	Size	OD	ID	Number	
Bit	Size	No. Nozzles	Size Nozzles	Float	Type

Tubular Data (Production):					
Tubing 1					
Size:	Weight	Grade	Depth	SITP	
Tubing 2					
Size:	Weight	Grade	Depth		
Packer	Type	Depth	Min. ID		
SSSV	Type	Depth	Min. ID		
Nipple 1	Depth	Min ID	Nipple 2	Depth	Min ID
Other Downhole Equipment					

BOP Information:					
Annular 1	**Annular 2**	**Ram 1**	**Ram 2**	**Ram 3**	**Ram 4**

Wellhead Information:				
Wellhead Type	**Model**	**Pressure Rating**	**Connector**	**Size**

Note: Santos Engineers to provide information on the BOP Configuration and Casing Profile



Appendix E – Well Control Equipment Summary

STORAGE OF CUDD EQUIPMENT - MOOMBA

Moomba	
1 x 2.4m x 2.4m shipping container (well response tools)	2 x CUDD rapid response boxes
1 x 6m x 2.4m shipping container (pump hoses, well response tools and workshop facilities)	4 x fold up skid mounted (heat Shield) monitors
1 x skid mounted pump with manifold	1 x Longhorn manifold

Qty	Description
1	Knack 68 Tool Box
18 ea.	Snaptite 2½" NST x 50′ Hoses (900 feet)
2 ea.	Elkhart Portable Ground Monitors (Model 8297)
2 ea.	Elkhart – V Select – Nozzles (500 gpm – 1,250 gpm)
4 ea.	2½″ male NST x 2½″ male NST adapters
4 ea.	2½" NST x 3" FMPT adapters
1ea	6" x 4" swage with 1502 unions
1 ea.	4" x 2" x 2" 1502 adapter with unions or 2" x 4" x 2" 1502 adapter with unions
2 ea.	2" 1502 x 2½″ LR adapters
	Complete box weight = 350 lbs (160 kg)
	Complete box dimensions = 60" wide x 37" tall x 30" deep

WELL CONTROL TOOL BOX INVENTORY - MOOMBA

Qty	Description
1 ea.	15" Crescent wrench
1 set	Ez outs
4 pkg	Hacksaw blades
1 pr	Needle nose pliers
1 pr	Regular pliers
1 ea.	20 oz. Ball peen hammer
Misc.	Grinder parts
1 ea.	1¼", 1⅛" & 1 $^{1/16"}$ x ½ drive sockets 1 $^{1/16"}$
15 pc	Combination end wrench set
8 pc	Screw driver set
1 ea.	Hand tool box
1 ea.	Large OD – ID calliper
1 ea.	½" air drill with crows foot connection
2 ea.	Long handle 8 lb brass hammers
1 ea.	Short handle 8 lb brass hammer
1 ea.	Long handle 6 lb brass hammer
2 ea.	Short handle 6 lb brass hammers
1 ea.	Wire brush
2 ea.	¾" hammer wrenches
2 ea.	7/8" hammer wrenches
2 ea.	1" hammer wrenches
2 ea.	1¼" hammer wrenches
2 ea.	11/8" hammer wrenches
2 ea.	13/8" hammer wrenches
2 ea.	1½" hammer wrenches
2 ea.	1 5/8" hammer wrenches
4 ea.	3/8" x 20 ft. chains with hooks
4 ea.	5/16" x 20 ft. chains with hooks
2 ea.	50 ft. x 1" air hoses with crow's feet connections
2 ea.	50 ft. x 3/8" air hoses with crow's feet connections
4 rolls.	1/2" x 50 ft. rope
1 ea.	25 ft. tape
1 ea.	48" chain tongs
1 ea.	36" chain tongs

Qty	Description
2 ea.	12" 'C' clamps
2 ea.	8" 'C' clamps
2 ea.	6" 'C' clamps
1ea.	50 ft. roll of 80 grit emery cloth
1 ea.	50 ft. roll of 60 grit emery cloth
1 bar	Babbitt
12 ea.	Rolls of friction tape
4 ea.	Duct tape
1 ea.	No. 2 cable cutter
1 ea.	O-ring kit
12 ea.	Rolls of 3/4" Teflon tape
1 box	Paint sticks
1 ea.	7" Air grinder
6 ea.	7" x 1/4" replacement grinder wheels (1 installed in grinder)
4 ea.	7" x 1/8" replacement grinder wheels
4 ea.	Straight wire wheels
4 ea.	Cup type wire wheels
2 ea.	Rolls Garlock packing
2 ea.	36" pipe wrenches
2 ea.	24" pipe wrenches
2 ea.	18" pipe wrenches
6 ea.	1" shackles
1 ea.	Complete air manifold
1 ea.	3 ton hand winch
1 ea.	2 ton hand winch
1 ea.	Complete monitor manifold for Rapid Response Equipment
1 set.	Drill bits

HAND TOOL BOX INVENTORY - MOOMBA

Qty	Description
1 ea.	½" Drive ratchet set
1 ea.	3/8" Drive ratchet set
1 ea.	Hacksaw with blade
1 ea.	½" Breaker bar
	Complete box weight = 900 lbs (410 kg)
	Complete box dimensions = 60" wide x 37" tall x 30" deep

EMERGENCY SERVICES RESOURCES - MOOMBA

This equipment can be sourced from current equipment available at Emergency Services – Moomba and transported to site with the CUDD Well Control equipment.

Respiratory Protection Equipment			
Number	**Item**	**Comments**	☐
6x	SCBA sets		☐
6x	Escape sets		☐
4x	Full-face (RA) masks respirators		☐
4x	Half-face mask respirators		☐
1x	Box of canister filters for masks		☐
2x	Air-lines		☐
1x	Air-skid		☐
12x	300 bar x 9 litre spare cylinders		☐
2x	Large plastic tubs		☐
1ea	Safety wash/Distal disinfectant		☐
1x	Roll of ROAR towel		☐
HAZMAT equipment			
12x	Disposable coveralls		☐
2x	Boxes of nitrile gloves		☐
1x	Roll of decontamination bags		☐
Working at Heights Equipment			
2x	Harnesses		☐
2x	Adjustable lanyards		☐
2x	Slings (anchor straps)		☐
Fire Fighting Equipment			
1x	Fire Appliance (Moomba or Ballera)	*Liaise with Emergency. Services T/L*	☐
4x	205L drums of Tridol AFFF-ATC foam	*Liaise with Emergency. Services T/L if required*	☐
1x	Air operated foam pump and hose	*Only required if foam transfer needed*	☐
Atmospheric Monitoring (Gas Detection)			
4x	X-Zone area detectors		☐
4x	X-am 5000's		☐
4x	X-am 2500's or 2000's		☐
4x	Charging cradles and charger		☐
1x	Bump test station and gas cylinder		☐
1x	Wind & Weather Instrument (Kestrel)		☐
Auxiliary Equipment			
1x	Portable Marquee		☐
3x	Trestle tables with folding legs		☐
2x	Large ice boxes (esky)		☐
6x	Cooling vests		☐
2x	Large dispenser of sun screen		☐
6x	Bunting tape (red/white)		☐
12x	Fly nets		☐
12x	Leather gloves		☐
6x	Rubber fire boots (assorted sizes)		☐

6x	Clear safety glasses		☐
6x	Tinted safety glasses		☐
Auxiliary Equipment			
6x	Plastic chairs		☐
1x	Whiteboard, markers & roll of chux		☐
1x	Bag of rags		☐
1x	Magnetic tags & label maker		☐
6x	Boxes of drinking water		☐
2x	E-flare kits (1 x Moomba & 1 x Ballera)		☐

Appendix F – Personal Response Log Sheet

Date	Time	Description	Contact (name and Number)

Notes:

- Print copies of this sheet and distribute to response team members to complete whilst performing Emergency Response Team duties
- Record key information and hand to log keeper/administrator
- Do not throw this sheet out as the information recorded may be used for investigative purposes

Appendix G – Emergency Response Numbers (ERN) (Example)

Santos — Wellsite Emergency Plan

(WELL) (CONTRACTOR)

Project Code:

Latitude - Longitude -

FOR EMERGENCY RESPONSE CALL TEL # 08 8675 6222

Santos Drilling Supt. in **Moomba**	08 8678 4406 SAT Ph 0147161874		Drilling Engineer (Adelaide) **(Primary Contact)**	Off: Mob:
Santos Drilling Safety Rep (Moomba)	08 8678 4425 or 08 8678 4426 **24hr. coverage**		Nearest Local Santos Base: **Moomba Supt., 24hr. coverage**	08 8678 4406
Local base: Moomba Comms	08 8675 6666		**MEDIC - Moomba Hrs - 7am to 5pm** Moomba Emerg. RFDS Moomba Nurse AH **MEDIC - Ballera Hrs - 6am to 4pm**	08 8678 4165 08 8675 6222 0404 806 594 07 46468107

CONTRACTOR/OPERATION phone numbers			Company phone numbers	
Rig Manager:	Office		Drilling Safety Rep., **Moomba**	08 8678 4425
Santos / OCR, Number **Satellite Phone in Blue**	**Office** Sat		Santos Drilling Supt. **Moomba**	08 8678 4406
Ensign 970 camp site	Office Kitchen(Main #)		Alternate 24hr Contact: Materials Co-ordinator **Moomba**	0417739895 08 8678 4199

Location & Telephone of Nearest Air Strip:			Telephone of Airstrip: Moomba Telephone of Airstrip: Ballera	08 8678 4513 or 08 8675 6614 07 4646 8103

Directions for driving to site:

Helicopter landing can take place at

Camp Site Co-ordinates: Latitude: Longitude: (km from site).