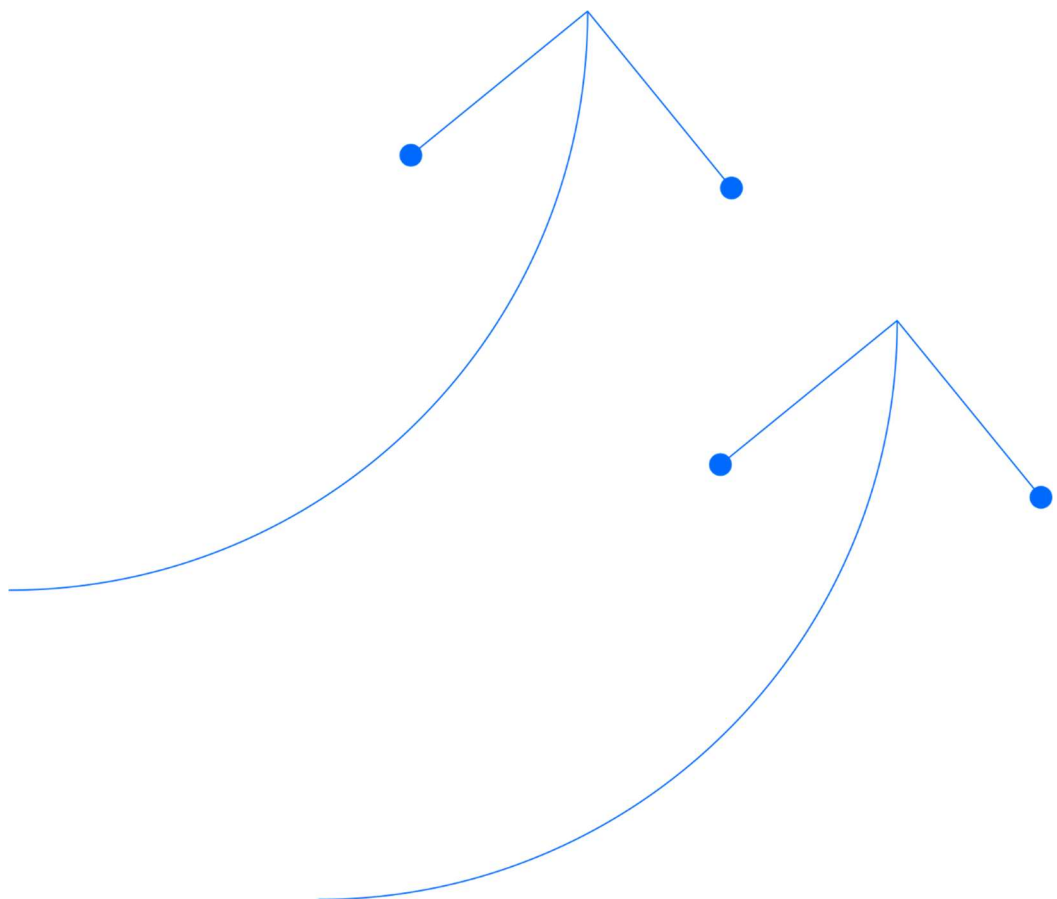




APPENDIX F: WASTEWATER MANAGEMENT PLAN

April 2026



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1. Introduction

This Wastewater Management Plan (WWMP) is in support of the EP 161 Beetaloo Basin Appraisal Activity Environmental Management Plan (EMP). This Plan sets out the management requirements for the Project in accordance with the *Code of Practice for Petroleum Activities in the Northern Territory 2025* (referred to herein as the 'Code') (Northern Territory Government, 2025) and considers all regulated wastewater generating activities proposed, including drilling, hydraulic fracture stimulation (HFS), appraisal, completion and decommissioning and maintenance.

This WWMP should be read in conjunction with the EMP, *Spill Management Plan* and *Emergency Response Plan*.

1.1. Project description

Santos is proposing to undertake a series of activities to expand their gas exploration and appraisal program within EP 161 of Tanumbirini Pastoral lease in the Beetaloo Sub-basin.

The Project proposes to undertake the following activities:

- Clearing and earthworks for two new well pad locations – The clearing and construction to create two new well pads and ancillary infrastructure (as listed below) at well pad locations referred to as Jibera South and Newcastle South.
- Drilling – Up to 12 appraisal wells, being either vertical or horizontal well types, distributed across the Jibera South and Newcastle South well pads.
- Operating, testing, maintenance and decommissioning – Up to 12 installed wells distributed across Jibera South and Newcastle South well pads.
- Hydraulic Fracture Stimulation (HFS) and well testing – Up to 12 appraisal wells will be tested with an average of 60 stages of HFS for horizontal wells and four stages for verticals.
- Wastewater Management – Each well pad will include open top and/or closed top tanks, storage tanks, drilling sumps, cutting pits and any transfer infrastructure within the well pad. This also includes transportation onsite and disposal of these wastes (unless otherwise approved for reuse or burial).
- Ancillary Infrastructure and Activities – Infrastructure and activities required to support the appraisal activities includes:
 - Water supply bores – up to ten bores installed at each well pad
 - Clean water storage – onsite tanks or dams
 - Groundwater monitoring bores – impact and control bores (included as part of total new bores proposed to be installed)
 - Borrow pits
 - Airstrip operations
 - Office, workshop and laydowns
 - Bulk material transport and storage
 - Installation and operation of camps at each the Jibera South and Newcastle South well pads
 - Traffic Management
 - Flaring – a routine activity during the well testing phase and will be managed in accordance with the EMP flaring controls and applicable regulatory requirements.

The proposed well pad layout for Jibera South and Newcastle South are provided in Appendix A – Well Pad Layout.

1.2. Code of practice

The Code provides a minimum standard that the onshore petroleum industry in the Northern Territory must adhere to. The Code of Practice applies to all regulated activities, including those associated with:

- Both conventional and unconventional oil and gas
- Exploration, appraisal, and production activities.

The Code frames the mandatory requirements for wastewater management associated with conventional and unconventional oil and gas exploration, appraisal, development and production in the NT.

1.3. Definition of wastewater

Under the Code, wastewater is defined as:

- Drilling fluids, drill cuttings, and cement returns (includes residual drilling waste, which may be solid)
- Flowback fluid (generated during HFS activities and the testing phases)
- Completion fluid, kill water/fluids, and well suspension fluids.

Note: The Code of Practice specifies that sewage, stormwater, and potable water (effluent) are excluded from the definition of wastewater.

2. Wastewater Generation

2.1. Activities

This section contains a description of the activities that will generate wastewater, as summarised in Table 1.

Table 1: Wastewater generating activities

Activity – waste resource	Waste Type
Drilling	Drilling fluids
	Cuttings and other solids
	Cement returns
Ancillary activities to Hydraulic Fracturing	Residual drilling wastes (both fluid and solids) and completion fluids
HFS	Produced fluid
	Drilling and completions fluids produced back from formation

2.2. Waste descriptions and volumes

The anticipated characteristics and volumes of wastewater (as per Section C2.1 and C2.2 of the Code of Practice) to be generated during the activity are presented below in Table 2.

Table 2: Waste generation

Waste	Volume per well	Description
Drilling returns – drilling fluids, cuttings and cement	600 m ³	Saturated solid mixture of cuttings, cement and groundwater. May contain chemicals depending on additives used in drilling fluid. Likely to have elevated salinity, with calcium, sodium and potassium-based salts being the main compounds

Drilling fluid	0.5–1.0 ML per well	Mixture of >90% groundwater and drilling additives
Produced fluids (including flowback)	14-28 ML flowback per well	Formation water

2.3. Wastewater Management Framework

Wastewater will be managed considering the following hierarchy principals:

1. Avoid: eliminate the generation of waste through design modification.
2. Reduce: reduce unnecessary resource use or substitute a less resource intensive product or service.
3. Reuse: re-use a waste without further processing.
4. Recycle: recover resources from a waste.
5. Treatment: treat the waste to reduce the hazard of the waste prior to disposal.
6. Disposal: disposal of waste if there is no viable alternative.

The Waste Management Framework (WWMF) for the design, approval and implementation of waste management as presented in the Code of Practice is provided below in Figure 1.

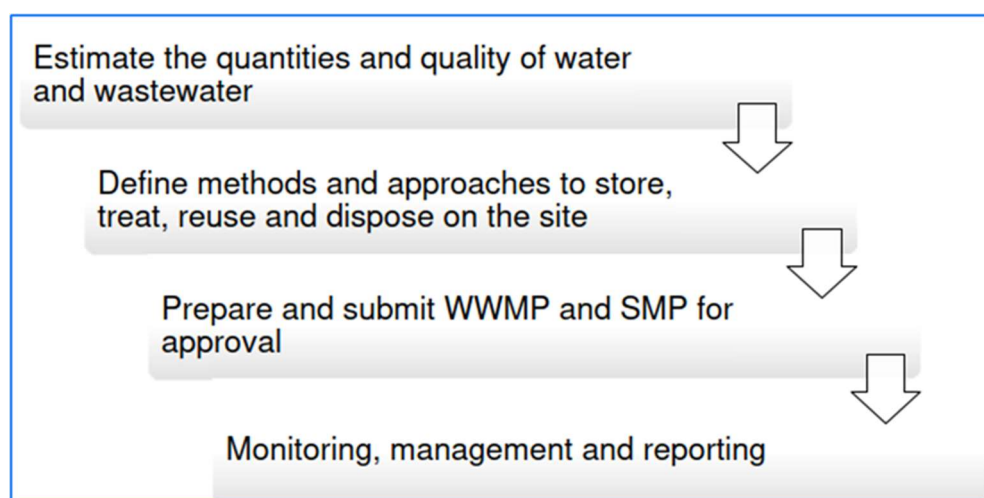


Figure 1: Waste Management Framework for Petroleum Activity (South: Northern Territory Government, 2025)

This WWMP has been developed in consideration of the waste management hierarchy and framework outlined above from the Code of Practice, and in the *National Waste Policy* (2018). Where practical, wastewater management activities are designed to sequentially and preferentially avoid, reduce, reuse, recycle, and treat before disposing of wastewater.

3. Freeboard Management

The climate of the permit area is arid to semi-arid with a monsoon-influenced wet summer between October and April, and a dry winter season between May and September, with September and April being transitional months with occasional rainfall. For freeboard calculation purposes, the wet season was assumed to occur between 1 October and 30 April.

Santos requested WRM to assess local rainfall characteristics to support the setting of freeboard requirements in accordance with the *Code of Practice: Onshore Petroleum Activities in the Northern Territory*. A Climate Assessment was completed to determine minimum freeboard requirements for a 1 in 1,000 Annual Exceedance Probability (AEP) for the proposed activities in EP 161 (WRM Water + Environment, 2025). A summary of the

calculated 1 in 1,000 AEP rainfall and required minimum seasonal freeboard is provided below in Table 3. The supporting Climate Assessment is provided as Appendix B – Climate Assessment to this plan.

Table 3: 1 in 1000 AEP Rainfall and minimum freeboard

Season	Minimum Freeboard (m)	
	Open-top tanks	Closed-top tanks
Dry season	0.5	0.5
Wet Season	1.1	0.5

A minimum freeboard will be maintained for on-site wastewater storages. For open-top tanks, pits and sumps, a freeboard of 1.1 m will be applied during the wet season and 0.5 m during the dry season. This is summarised in Section 3.11.3 of the EMP and detailed further in the WWMP's Appendix B (Climate Assessment). Closed-top wastewater tanks may be used during the wet season to limit rainwater ingress and preserve available storage capacity. Where tanks are covered, a minimum of 0.5m freeboard will be throughout the wet season

These minimum freeboards are based on the findings of the project Climate Assessment and are managed in conjunction with rainfall forecasting, routine level monitoring and wastewater transfer procedures to reduce the risk of overtopping. During significant rainfall, freeboard may be temporarily exceeded (i.e. the freeboard is being used as intended as a mitigation measure); however, Santos will reinstate the applicable minimum freeboard requirements as soon as practicable following the rainfall event. Refer to Section 5.3 for wastewater transfer procedures.

4. Drilling Fluids and Cuttings

The following section provides an overview of the management of recovered after use and reuse, including all drilling returns, including waste drilling fluids, muds, cuttings and cement returns. Management of drilling fluid as a waste must manage the liquid and solid components appropriately.

4.1. Collection and Storage

Drilling returns including fluids, cuttings, muds, and cement returns will be directed to the inground drilling sumps on each well pad (Appendix A – Well Pad Layout). Separate sumps for fluids and cuttings are planned to be constructed as depicted in the well pad layout figures in Appendix A – Well Pad Layout.

The drilling sumps have been designed to store up to 2,400 m³ of material, which is the anticipated upper volume for up to 3 wells per well pad. Each sump will be excavated to the required depth with indicative dimensions presented in Appendix P. The sumps will be designed to accommodate the upper volume and the minimum freeboard requirement as presented in Section 3.

The drilling sump(s) will include engineered pits (rolled and compacted), lined with a waterproof membrane in accordance with Section C.4.1.2 of the 2025 Code of Practice¹ for inground pits. Coletanche™ waterproof geomembrane (or equivalent) may be utilised, which consists of five layers:

- A highly resistant anti-root film able to withstand puncturing by vegetation or rough substrates.
- Glass fleece which ensures dimensional stability.
- A non-woven geotextile reinforced structure which is highly resistant to tearing and puncturing.
- An elastomeric bitumen binder ensures that the geotextile is waterproof and resistant to ageing.
- A coating of sand ensures that workers can move on the surface in all weather conditions to carry out maintenance work. It also provides a rough surface which allows coverage of the membrane by soil.

¹ The permeability of less than 10⁻⁹ m/s tested in accordance with AS 1289.6.7.2 and with resistance to tearing >0.5kN (ASTM D 4073); static puncture >0.5kN (ASTM D 4833) and tensile strength >20 kN/m (ASTM D 7275)

In some circumstances, a conventional HDPE liner may be used. Where a HDPE (or alternative) liner is used, the liner specification shall meet or exceed the Code of Practice requirements (C.4.1.2).

Below in Figure 3 is a visual example of the drill cutting and fluid pits separation located within the well pad noting that proposed site specific dimensions for sumps are provided in Appendix P – Engineering Drawings.

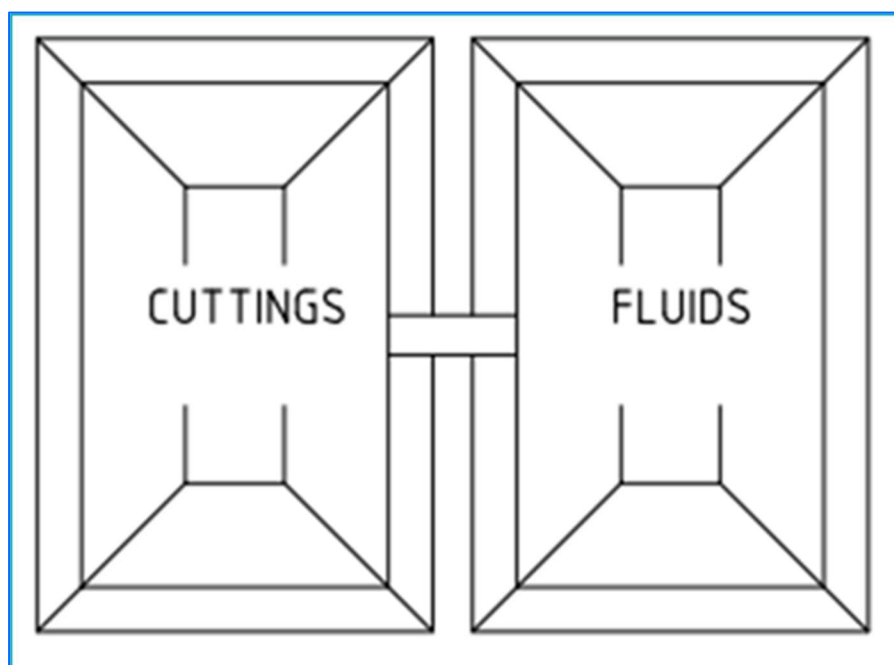


Figure 2: Indicative drilling fluid and cuttings pit for the drilling campaign

4.1.1. Drilling cutting volume

Drilling solids will be separated from the drilling fluids via solids control equipment (e.g. shale shakers) on the drilling tanks/pits. The drilling solids/cuttings/fluid will be transferred to the drilling sumps for storage. Drilling fluids will be collected from the drilling sumps and transferred to a separate wastewater tank for temporary storage. The fluids will either be reused or transported off-site for disposal. An indicative estimate of drilling solids and fluid volumes per well has been summarised in Table 4.

Table 4: Indicative volume of drilling solids and liquids

Material	Per Well (m ³)	Estimate for well pad (m ³)
Drilling Solids/ Cuttings	600	2,400
Drilling Fluids	600	2,400

4.2. Geology

The anticipated geology of the Beetaloo Basin Appraisal Project is considered to be consistent with other offset exploration wells completed within EP 161. Through recent seismic acquisition, the completion of previous exploration at Newcastle South, Mount Brown and Jibera South, Santos anticipates a consistent geology profile to that previously experienced. Table 5 provides an overview of the formations at Mount Brown, Jibera South and Newcastle South highlighting this consistency.

As shown in Table 5 the formation type, widths and depths are not anticipated to change significantly at Jibera South and Newcastle South compared to previously completed drilling activities.

Table 5: EP 161 proposed formation depths (top of formation)

Formation		Jibera South Depth (m-TVD)	Newcastle South Depth (m-TVD)	Mount Brown Depth (m-TVD)	Description
Surficial Deposits		9	9	-	Claystone, siltstone and minor sandstone.
Anthony Lagoon Beds		145	92	NA	Regional Aquifer. Sandstone, siltstone and Dolomitic limestones.
Gum Ridge Formation		305	138	77	Regional Aquifer. Minor grey brecciated limestone, pink to pale brown cryptalgal laminate.
Un-named Sandstone		425	258	217	Fine to very coarse grained, friable quartz to lithic sandstone with minor shale beds and basal pebbly sandstone to conglomerate.
Cox Formation		490	478	597	Thinly interbedded siltstone, laminated siltstone to claystone and very fine-grained sandstone.
Bukalara Sandstone		1,126	1,240	1,167	White, light grey to brown, fine- to coarse-grained quartz sandstone with lesser fine-grained micaceous sandstone .
Upper Kyalla		1,281	1,355	1,312	Interbedded siltstone, mudstone and very fine-grained quartz sandstone.
Lower Kyalla		1,713	1,701	1,841	Fine- to coarse-grained quartz sandstone, with interbedded siltstone, mudstone.
Moroak Sandstone		2,013	2,001	2,084	Medium to fine quartz sandstone.
Wyworrie Member		2,407	2,322	2,659	Alternating, interbedded and interlaminated mudstone and siltstone.
Amungee Member		2,853	2,821	3,143	Thinly interbedded, dark grey to brown-black organic-rich to -poor claystone, pale grey siltstone and rare, light grey fine-grained sandstone.
Amungee Member	C Shale	2,916	2,884	3,205	Organic-rich carbonaceous with varying clay content shale.
	B Shale	3,117	3,086	3,426	Primary Target - Organic-rich carbonaceous with varying clay content shale.
	A Shale	3,269	3,228	3,497	Organic shale with varying clay content and potentially favourable brittleness properties.
Kalala Member		3,279	3,238	N/A	Interlaminated mudstone and siltstone.

4.3. Containment screening methodology

A contaminant screening process will be implemented by a suitably qualified and trained competent personnel², (SQCP) to confirm that residual drilling material (RDM) is suitable for on-site burial in accordance with the approved burial methodology and the *Code of Practice for Petroleum Activities in the Northern Territory* (2025). The following presents an overview of the contaminant screening methodology. Appendix C – Contaminant Screening Methodology includes detailed background information, a conceptual site model (CSM) and detailed

² A competent person is someone who has the knowledge, skills and abilities to perform a task or role effectively and safely. They have acquired this competence through training, qualifications, or experience, and can demonstrate the ability to apply their knowledge to the specific task at hand.

basis for the screening methodology. This will be reviewed and implemented by the SQCP undertaking the RDM contaminant screening process.

4.3.1. Objectives

The purpose of contaminant screening is to:

- Evaluate the presence and concentration of constituents of potential concern (COPC) against adopted screening criteria.
- Confirm that potential contaminant exposure pathways for respective COPC are incomplete or that concentrations of COPC in the buried RDM are below levels that would pose a risk to human health or the environment.

4.3.2. Representative Sampling Program

Representative sampling of RDM solids, including analysis of leachate, will be undertaken following the removal of bulk drilling fluids from the cuttings pit. The sampling program will be undertaken in accordance with Section C.4.1.2 of the Code of Practice and the Wastewater Monitoring Program (refer to Section 9). The specific sampling program will be developed by and implemented under the oversight of the SQCP.

The sampling and analysis program will be designed to ensure statistical representativeness of the RDM based on the requirements outlined in Schedule B2 of the ASC NEPM (NEPC, 2013) with reference to standard AS 4482.1-2005 (Standards Australia, 2005). It is anticipated that the main body of the RDM will be characterised through the collection of a sufficient number of samples (e.g. more than ten) distributed across the stockpile and from representative depth intervals to capture spatial variability in contaminant concentrations. Ancillary RDM materials, such as smaller quantities of RDM located in the secondary cuttings pit, will also be sampled to characterise these materials adequately.

4.3.3. Analysis Requirements

All constituents listed in Table 9 of the Code of Practice will be analysed, including the RDM solids and leachate component (refer to Appendix D – Drilling Waste Assessment Analytes). Required analysis parameters for RDM solids and leachate are provided in Appendix E – Screening Criteria for RDM Solids and Leachate (note that Appendix E reflects constituents listed in the Code of Practice with some additional details).

4.3.4. Screening Criteria Assessment and Exposure Pathway Evaluation

The SQCP will review analytical results and determine whether any exceedances represent a material risk to human health or the environment under the approved burial methodology. This step will include comparison of analysis results for COPC to the adopted screening levels in Appendix E – Screening Criteria for RDM Solids and Leachate.

The SQCP will also undertake an exposure pathway analysis to identify potentially complete and incomplete exposure pathways with the RDM burial methodology in place. Where exceedances occur for parameters associated with potentially complete exposure pathways, the SQCP will review the need for additional assessment, mitigation, or adjustment to the burial methodology (e.g. increased cover depth or modified location). If a criterion is exceeded but the relevant exposure pathway is incomplete, the exceedance will be documented, but it will not be considered to represent a risk under the proposed burial scenario.

4.4. Risk assessment of residual drilling material burial

An assessment of the environmental impacts and risks associated with the residual drilling material (RDM) has been undertaken based on data from an offset (or analogue) well pad, Mount Brown, in accordance with the Code (see Appendix F). The assessment determined that land disposal of the RDM is acceptable, with risks reduced to as low as reasonably practicable (ALARP), provided that site-specific data and sampling and analytical results for Jibbera South and Newcastle South are obtained and reviewed by a SQCP to confirm that the RDM complies with the requirements of the WWMP. Certification from a suitably qualified third party, in accordance with Section C.4.1.2 (f) of the Code, confirms that the proposed RDM burial methodology will not result in environmental harm

(refer to Appendix G – Certification of Residual Drilling Material Burial Methodology). If the RDM burial does not conform to the methodology specified in this WWMP, additional certification of the modified or alternative burial methodology by a suitably qualified third party will be required before that methodology can be implemented

Pending compliance with the requirements of this WWMP, drilling material will be buried onsite in line with Section 4.4 and either be disposed of during operations (i.e., between the drilling each appraisal well to accommodate storage volume requirements) or upon completion of drilling or well testing operations (with the potential for on-site storage of material in accordance with Section C.4.1.2 of the Code of Practice).

4.5. Management and disposal

4.5.1. Site selection of residual drilling material disposal

Based on data available (refer to Appendix C – Offset Well Analysis Results and Screening Summary), the certification from a suitably qualified third party (Appendix G) and previously approved and completed RDM methodologies, on-site selection of final burial location screening will be completed using the following criteria and mitigations to be implemented during the operations of the Regulated Activity:

- The screening criteria assessment and exposure pathway evaluation confirm there are no unacceptable exceedances of the screening criteria and no unacceptable exposure pathways.
- The environmental risks associated with the burial method are ALARP and in accordance with the EMP.
- The final drill cuttings and residue burial location must be designed that it:
 - Achieves a minimum 1.5 metre cover.
 - Is located within the EMP approved well pad footprint and outside the 1 per cent AEP inundation area.
 - Is designed and engineered to meet the outcomes of the RDM risk assessment and EMP.
- The presence of Cretaceous claystone, siltstone and sandstone sequences overlying the CLA or shallow groundwater-bearing zone within the Cretaceous formations will be confirmed to be of sufficient thickness to preclude infiltration of water in appreciable quantities (i.e., >50 metres total thickness and/or siltstone/claystone sequences >6 metres in total thickness overlying any relevant aquifer/groundwater-bearing stratigraphy).

4.5.2. Storage and onsite Management

All fluids collected in the drilling sumps (including rainwater / stormwater) may be transferred to wastewater tanks for storage, evaporation and potential reuse (where suitable). Evaporation is the main mechanism used to reduce the volume down to as low as possible. The residual concentrated liquid waste will be disposed of off-site at a licenced facility in accordance with the *NT Waste Management and Pollution Control Act 1998*.

Closed-top wastewater tanks may be used during the wet season to limit rainwater ingress and preserve available storage capacity. The drill cutting pits may be covered, and any captured water during rain events will be managed in accordance with Section 3.11.5 of the EMP.

Closed-topped tanks are not designed to capture or store rainwater / stormwater. Any rainwater / stormwater temporarily retained on the tank roof (e.g. in the roof creases or ridges) will not come into contact with wastewater contained within the tank, and will be managed as rainwater / stormwater as per the EMP Section 3.12.4.

Drill cuttings and residue will be disposed of to land, via a burial method, where suitable in accordance with Section C.4.1.2 of the Code of Practice (i.e., subject to leachability testing results). Recycling and reuse of all solids waste should be maximised, to minimise volume of waste that must be disposed of on-site or transported and disposed off-site.

The proposed Jibera South and Newcastle South burial pits will be located within the final well pad disturbance areas, in the most practicable location based on operational requirements. The proposed areas will measure approximately 1,500 m² in area with a minimum three metre depth below final grade (capable of containing the

anticipated drill waste volumes plus sufficient cover). The burial pits will be located within the existing well pad footprint and will be suitable to contain the anticipated volume required for burial and achieve a cover of 1.5 metres. Refer to Section 4.4 for location assessment details.

The land surface elevation in the burial areas (i.e., the well pads) are outside the 1 per cent AEP inundation (flooding) extent. If any of these are not achievable, then the site cannot be used for burial purposes. An indicative burial profile is provided in Figure 4. The complete Engineering Plans are provided in the Environmental Management Plan (EMP) Appendix P.

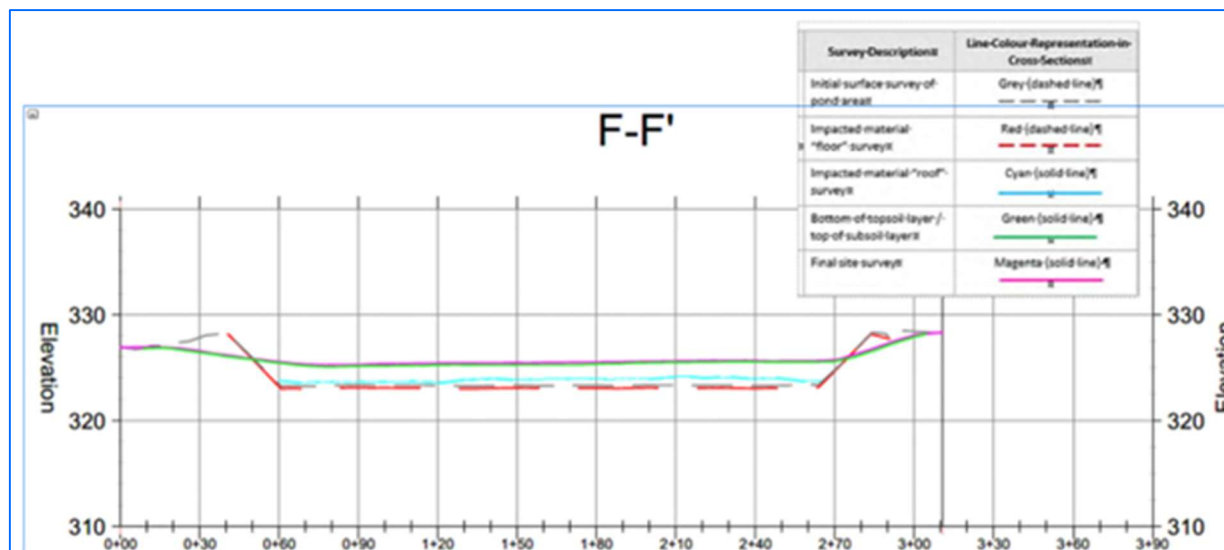


Figure 4: Indicative burial profile

The burial method developed for Jibera South and Newcastle South is described below in Table 6.

Table 6: Onsite management procedure for RDM burial

Step	Method
Transfer of cuttings from engineered pit to burial pit	
1	Complete an as-constructed survey of the burial pit.
2	Transfer material from the cuttings pit to the burial pit and spread evenly across the base of the burial pit to create a level surface. Note that standing liquids in the cuttings pit are to be removed to a suitable location for storage (evaporation) and/or off-site disposal. If an acceptable (i.e. demonstrates compliance with C.4.1.2 (b)) biodegradable liner is identified, this can be left in situ and the material can be buried within the existing pit without the need to transfer. Material may also be mixed with native soils to achieve compatibility and formability required to reduce slumping. If a non-biodegradable liner is used, it will be removed from the cuttings and fluid pits during decommissioning of the pit and disposed of offsite in accordance with the <i>Waste Management and Pollution Control Act 1998</i>.
3	Upon completion of transferring all material from the cuttings pit to the burial pit, site measurements of the freeboard allowance will be completed. Confirm that the depth of cover >1.5 m relative to final land surface will be met.
4	Backfill the remaining burial pit void using stockpiled native soils (previously excavated from the pit). Backfill will be completed using a bulldozer to push the materials into the pit, and other excavation equipment, as required. Care is to be taken to avoid wet material escaping from the sump footprint during backfill works, or causing slumping post backfill works.
5	Track roll backfilled pit using bulldozer. This may be completed in lifts of approximately 0.3 to 0.5 m to aid in compaction.
6	Trim land surface to final grade, consistent with the land surface in the surrounds. The reinstated pit area should be slightly mounded with a camber of 0.5% to 1.0% to shed water, and to allow for minor settling over time. The mounding in the centre of the pit shall not exceed 0.15 m above the surrounding grade level (which would create a

	gradient of approximately 1% sloping from the centre of the reinstated void). The edges of the reinstated void shall be blended with the surrounding landform so that there are no “steps” in the landform or features that would promote channelisation of water flow.
7	Complete final inspection of reinstated land surface and prepare photographic evidence to demonstrate that > 1.5 m cover over the buried drilling residue and cutting material layer has been achieved.
8	Take photographs of the reinstated area to document completion.
General	
9	All records of this method are to be retained for five years.

4.5.3. Offsite Disposal

If the material is unsuitable for on-site disposal (as per Section 4.3.4), the material will be transported off-site to an alternative suitable exploration location or a licenced facility. Off-site disposal will be undertaken in accordance with the *NT Waste Management and Pollution Control Act 1998*.

4.6. Record-keeping Requirements

Records associated with the management, assessment, certification and burial of Residual Drilling Material (RDM) will be maintained to demonstrate compliance with Section C.4.1.2 of the Code of Practice and the requirements of this WWMP. These records must be retained for a minimum period of five years.

The following information must be documented and retained:

4.6.1. Sampling, Analysis and Screening Records

- Field records describing the RDM sampling program, including sampling locations, depths, methods, and chain-of-custody documentation.
- Laboratory certificates of analysis for all RDM solids and leachate samples, including QA/QC information and analytical results for all constituents listed in Table 9 of the Code of Practice and Appendix D of this WWMP.
- Screening assessments prepared by the suitably qualified and competent person (SQCP), including pathway evaluations, comparison against adopted screening criteria (Appendix E), and confirmation that COPC concentrations meet requirements for on-site burial.
- Any documentation of exceedances, and justification where exceedances are deemed not to pose unacceptable risk due to incomplete exposure pathways.

4.6.2. Site Suitability Records

- Scaled maps showing burial area relative to the 1% AEP flood inundation area and other sensitive environmental areas (e.g. groundwater dependent ecosystems).
- Review of site-specific lithology and hydrostratigraphy and applicability of infiltration model, including an updated infiltration model report if an updated model is warranted.

4.6.3. Burial Methodology Verification

- As-constructed geospatial data for each burial area/pit, including of burial area pit dimensions and location.
- Estimate of the quantity of RDM solids to be buried.
- Photographic records demonstrating the removal of standing liquids, spreading and levelling of material.
- Photographic and/or survey evidence confirming that the minimum 1.5 m cover thickness has been achieved following reinstatement.
- Photographic records and/or report demonstrating the final reinstated land surface in the burial area.

4.6.4. Third-party Certification

- Certification statements from a suitably qualified third party confirming that the burial methodology complies with Section C.4.1.2(f) of the Code of Practice.
- Where the RDM burial deviates from the methodology specified in this WWMP, records of supplementary certification for any modified or alternative burial methodology must be retained prior to its implementation.

5. Flowback and Production Fluids

The following section provides an overview of the management summary associated with flowback fluid, including waste injected stimulation fluid and produced water.

5.1. Volume

A potential load fluid recovery of 10 to 20 per cent of injected stimulation fluid over the testing duration is anticipated based upon previous Tanumbirini results. A flowback wastewater production volume of approximately 14-28 megalitres per well is anticipated. The majority of flowback is expected to be generated in the first 4 months of the well test.

The predicted maximum volume of flowback to be stored at each site is approximately 54 megalitres (when two wells are drilled at one pad). This volume allows flowback from up to 3 wells at each site. Review of the site layout will occur prior to the HFS stage to ensure sufficient tank storage can be achieved within the maximum number of tanks specified in the EMP. Storage capacity will be managed through review of achievable HFS stages, number of wells per pad per year, stimulation methodologies, reuse in HFS where suitable, evaporation and off-site disposal where required.

5.2. Quality

The flowback fluid will comprise a blend of formation water and HFS fluid. The quality of flowback encountered at Tanumbirini McArthur Pilot flowback monitoring is summarised below in Table 7. The project flowback is anticipated to be of similar quality.

Table 7: Indicative flowback quality based on Tanumbirini Flowback Results

Parameter	Historical Flowback Characteristics
pH	6.13 – 7.50
Salinity (TDS)	7,310 – 20,000 mg/L
Major ions	Bicarbonate present at levels consistent with stimulation fluid.
Total nitrogen as N	21.5 – 63 mg/L
Metals	Boron (Max. 24,400 µg/L), barium (Max. 17.5 mg/L), iron (Max. 348 mg/L), manganese (Max. 42.8 mg/L) and strontium (38.3 mg/L) main metal elements detected.
Benzene, Toluene, Ethylbenzene and Xylenes (BTEX)	Non-detect (below limit of reporting (LOR))
Petroleum hydrocarbons (TRH Sum C10-C40)	4,360 – 801,000,000 µg/L
Polycyclic Aromatic hydrocarbons (PAHs)	Non-detect (<LOR)
Phenolic compounds	m&p Cresol <25 µg/L
Radionuclides	Max Gross alpha 2.29 Bq/L, Max Gross beta 1.24 Bq/L

5.3. Collection and Storage

On-site wastewater management will be an adaptive process, with tank and treatment capacity adjusted (added or removed) to meet operational requirements (including meeting mandatory Code of Practice requirements). Review of the site layout will occur prior to the HFS stage to ensure sufficient tank storage can be achieved. The total volume of storage will be determined by the volume of water required for the stimulation and the number of well layout and HFS stages confirmed.

Storage onsite may consist of:

- Up to 8 x 13.5 ML tanks in total (4 each well pad), or
- Up to 16 x 7 ML tanks (8 each well pad), or
- A mixture of tank sizes ranging from seven megalitres to 13.5 megalitres to fulfil a conservative flowback demand and various configurations subject to the anticipated volumes and hardstand available within the well pad.

Maximum storage requirements per 3 well yearly campaign is up to 54 ML. Tanks are to be double lined with built in leak detection (between the liners). Depending on the tank design, some may be periodically converted to enclosed tanks (have lids installed) and vice versa, as flowback volume increases/decreases. Covers may be fitted to any approved wastewater tank during the wet season to limit rainwater ingress and preserve available storage capacity. This allows open-top tanks to be used to maximise evaporation when appropriate, while maintaining the ability to operate tanks as closed-top tanks when wet season conditions require reduced rainwater ingress.

The open top tanks will be operated with sufficient freeboard available to accommodate the total rainfall anticipated based on a 1:1,000-year AEP. As per the assessment summary in Table 3, this equates to a minimum 1.1 metre wet season freeboard and a minimum 0.5 metre dry season freeboard. As tanks are fitted with covers during the wet season, these closed-top tanks will be operated with a minimum freeboard of 0.5 m.

Enclosed tanks will be on-site with enough capacity to receive wastewater transfers required to maintain the 1:1,000 AEP freeboard requirements for all open flowback wastewater tanks (providing additional contingency storage capacity if there is potential for open tank capacity to be exceeded). Should the freeboard of an open tank storing flowback be exceeded, wastewater transfers (via suck truck or similar utility) will commence as soon as practicable to return the fluid under the freeboard requirements. Enclosed tanks will be vented.

Wastewater transfers will be undertaken via suck truck or similar utility. However, primary controls and mitigations to maintain freeboard requirements are controlling well flow rates and monitoring weather conditions to ensure freeboard requirements are appropriately managed.

Pumping infrastructure will be maintained to transfer drilling fluid and flowback wastewater into enclosed storage at least 8 hours prior to a significant rainfall event (as defined in Section 6). Weather forecasts will be monitored daily during operations as specified in Section 8.6.1 of the EMP. Sufficient pumping redundancy will be available to accommodate pump failures.

5.4. Management During Flowback

Management of flowback will occur in accordance with the below items:

- Priority will be given to the reuse of flowback water as make-up fluid in operations.
- Discharge of flowback wastewater to surface water bodies or onto land will not be permitted.
- Flowback water will be held in above-ground storage vessels.
- All tanks will be double-lined and equipped with integrated leak detection systems.
- Except when being managed by evaporation in open-top tanks or being reused in accordance with this WWMP, all flowback wastewater will remain in enclosed storage tanks.
- The Project will maintain sufficient enclosed storage capacity to manage the total volume of flowback water on-site at any given time.

- If the freeboard in an open flowback tank is exceeded, immediate action must be taken to transfer fluid and bring levels back within required limits.
- Closed-top tanks may be used during the wet season and significant rainfall periods to limit rainwater ingress and preserve available storage capacity.
- Enclosed tanks will be adequately vented to avoid the accumulation of flammable gases.
- Tank construction and operation will account for environmental conditions and potential impacts.
- Operational open top tanks will maintain a minimum freeboard level (as per Table 3) capable of handling a 1-in-1000-year AEP wet or dry season event.
- Closed-top tanks will maintain a minimum freeboard of 0.5 m.
- Off-site disposal of flowback water will be reduced through on-site treatment using open top tanks, except during significant rainfall events.
- Surface pipelines located within the well pad will be used only for temporary water transfers and will be cleaned and decommissioned after each use.
- Maximum Water Level (MWL) indicators will be clearly displayed on open top tanks to define freeboard limits and monitor compliance with freeboard requirements.
- Flowback wastewater will be transferred to enclosed tanks when a significant rainfall event is forecast (as defined in Section 6). Transfers will be scheduled and completed at least eight hours prior to rainfall onset, while retaining a minimal volume to anchor the liners. Transfers will be undertaken to ensure open tanks maintain the applicable minimum freeboard requirement (as per Table 3) for the forecast event.
- Pumping systems capable of transferring flowback water into enclosed tanks will be maintained so that transfers can be completed eight hours prior to rainfall onset. Redundancy will be built into the system to ensure functionality in case of pump failure.
- Interconnected tanks will be engineered to prevent cascading failures or unintentional release from multiple units.
- All tanks will comply with relevant Australian Standards (such as AS1554.1 and AS3990), and installations will follow a documented QA/QC process overseen by qualified contractors.
- Tanks will be designed to exclude livestock and wildlife, and all exploration sites will be securely fenced to prevent unauthorised access.
- Tank levels will be monitored daily during the wet season and weekly during the dry season, either manually or remotely, with pre-defined management responses in place to prevent overflow. Operations will be halted if freeboard cannot be maintained.
- Upon decommissioning of tanks, residual solids, brines, and liners will be removed and transported by a licensed contractor to an approved waste facility, in compliance with the *NT Waste Management and Pollution Control Act*.
- During removal of tank contents, precautions such as vacuum trucks and temporary containment (bundling) will be used to capture any remaining fluids and minimise environmental exposure.

5.5. Management of Disposal

Flowback will be managed using two primary methods – evaporation and recycling. Residual flowback liquids (after treatment and recycling / re-use) that are unsuitable for use, and evaporation brines will be transported to a licenced interstate disposal facility (e.g. Hydrea Tenant Creek, Pure Environmental Jackson, Queensland or alternative approved locations) with the appropriate interstate waste transport consignment authority as per the *National Environmental Protection Measure (NEPM)* as implemented under the *NT Waste Management and Pollution Control Act 1998*.

Evaporation rates have been estimated using conservative planning assumptions informed by previously observed evaporation rates for comparable wastewater storage arrangements in EP 161. On this basis, indicative evaporation rates of up to 0.35 ML per month for open tanks and 0.25 ML per month for enclosed tanks have been applied for storage and water balance planning. The lower evaporation rate for enclosed tanks reflects the

reduced exposed surface area, with evaporation occurring via vents that allow hydrocarbons in the flowback fluid to be safely released rather than retained beneath the cover. Actual storage levels and available freeboard will be monitored throughout operations, and wastewater volumes will be managed in accordance with the WWMP to ensure the required freeboard is maintained regardless of the assumed evaporation rate.

Flowback fluids will, where practicable, be reused as make-up water for stimulation activities. Flowback, raw groundwater and stimulation chemicals will be combined within an on-site storage tank prior to downhole injection. As flowback fluids are expected to be saline, blending with raw groundwater will be undertaken to reduce electrical conductivity to suitable levels before reuse. Monitoring of flowback fluids is described in Section 5.6.1, with sampling and analysis results used to inform decisions regarding reuse, recycling or disposal.

5.6. Monitoring - storage

The open top tanks will be operated with sufficient freeboard available to accommodate the total rainfall anticipated based on a 1:1,000-year AEP for the duration the tank is in operation. As per Table 3, this equates to a minimum 1.1 metre wet season freeboard and a minimum 0.5 metre dry season freeboard. Closed-top tanks will be operated with a minimum freeboard of 0.5 m.

Wastewater volumes within the open top tanks will be monitored daily during operations to ensure sufficient freeboard remains and the level is under the MWL. Levels will be monitored weekly during the dry season and daily during the wet season. Monitoring may be undertaken via physical inspection during active operations, or by remote cameras or sensors during non-operational periods.

5.6.1. Flowback Monitoring

Flowback fluid monitoring will be conducted in accordance with Code of Practice. The following is noted as requirements for the flowback fluid monitoring and sampling program:

- Flowback fluid monitoring will utilise continuous monitoring (sampling frequency of at least once per 24 hours) for electrical conductivity, pH and temperature.
- Sampling and laboratory analysis of flowback fluid will be conducted for the analytes listed in Section C8 of the Code of Practice and will be completed weekly until sufficient data has been gathered to ascertain the chemical composition of the flowback fluid against the criteria described within the *Wastewater Management Plan*.
- The monitoring program must measure flowback fluid volume by recording the cumulative flowback fluid volume for each well at one month, three months, six months, and 12 months after flowback has commenced.

6. Significant Rainfall Events

Drilling fluid and flowback, wastewater must be able to be transferred into enclosed tanks when a significant rainfall event is forecast (noting a minimum volume of wastewater will be required to be maintained within each tank to secure the liners). This transfer must be completed at least 8 hours prior to the predicted commencement of the significant rainfall event. A significant rainfall event is defined as the predicted 4-day cumulative total rainfall exceeding 300 mm.

Santos will monitor daily weather forecast and weather alerts for the region for early detection of potential significant rainfall events as per Section 8.6 of the EMP. Where a potential significant rainfall event is forecast, the above procedure will be implemented.

7. Access Control

Management and control methods will be implemented to minimise the risk of wildlife, stock, and human receptors interacting with stored waste. Control measures to prevent interactions of wildlife, stock and human receptors are detailed below:

- Fencing of the well pad with installation of signage at the main well pad access to limit trespassers.
- Tanks will be designed to prevent the ingress of wildlife and stock.
- Fauna ladders to be installed in open top tanks.
- Implementation of fauna deterrents.
- Tank walls high enough to prevent ingress of non-flying wildlife and stock.
- Daily visual inspection of open storage / open tanks, including observation of trapped wildlife and stock, will be conducted and reported in the daily report during operations.

8. Decommissioning

When the wastewater tanks are decommissioned, the associated residual solids, brines and liners will be removed and disposed of at an appropriately licensed waste disposal facility by a licenced contractor as per *NT Waste Management and Pollution Control Act 1998*.

During removal of the solids within the liner, efforts will be made to contain any residual fluid. This includes the use of vac trucks and temporary bunding during tank deconstruction.

Where possible, tank decommissioning will occur during the 'dry' season to avoid delays due to wet season prolonged rainfall.

9. Wastewater Monitoring Program

The wastewater monitoring program to be implemented is summarised in Table 8 below.

Table 8: Wastewater Storage Management Response

Component	Location	Monitoring Requirement	Frequency
Rainfall forecast	BOM Climate forecast and alert	Review of BOM climate forecast for region and weather alerts.	Daily – During operations.
Drill cuttings	Drill sump	Sampling, analysis and interpretation as per Section C.4.1.3 of the Code of Practice.	Prior onsite disposal to land.
Stimulation source water	Source water used for stimulation	Sampling and laboratory analysis of stimulation water for analytes listed in Section C8 of the Code of Practice.	Prior to HFS.
Stimulation volume	Each well stage	Total volume of stimulation fluid pumped.	Prior to each HFS stage.
Flowback characterisation	End of pipe	Continuous monitoring of electrical conductivity, pH and temperature.	Minimum once per 24 hours.
	End of pipe	Sampling and laboratory analysis of flowback fluid for	Weekly until sufficient data has been gathered.

		analytes listed in Section C8 of the 2025 Code of Practice.	
	Flow meter	Cumulative flowback fluid volume recorded for each well.	One month, 3 months, 6 months and 12 months intervals.
Flowback Storage	Flowback Storage Tanks	Stored volume and available freeboard management level and fauna interactions.	Daily during the wet season, weekly during the dry season (visual or telemetered camera).

10. Wastewater Storage Response Actions

The response actions to be implemented in the case of storage management level exceedances is summarised in Table 9 below.

Table 9: Wastewater Storage Response Actions

Monitoring Item	Event/ Occurrence	Criteria	Response Action
Significant rainfall event	Significant rainfall event predicted.	Predicted 4 day cumulative total rainfall exceeds 300 mm.	Flowback fluid must be transferred to enclosed storage at least 8-hours prior to the predicted commencement of the significant rainfall event.
Drilling sump (engineered pit) level monitoring (fluids and cuttings)	Drilling sump level exceedance.	The volume of drilling fluid/cuttings exceeds the required sump freeboard level.	- Drilling fluid/cutting storage into the sump/tank to cease until below freeboard level. - Return levels to freeboard as soon as reasonably practicable post rain event. - If freeboard is reduced by more than 50% of the original limit: - Notify DLPE in accordance with the Recordable incident procedure (Section 11.2). - Develop case specific action plan to prevent the overflowing and future exceedance of freeboard level. - Actions are to be agreed to with DLPE and are to be implemented.
Flowback wastewater tank level monitoring	Open flowback storage tank level exceedance.	The volume of flowback stored in an open tank exceeds the required tank freeboard level.	- Transfer of flowback to onsite enclosed tanks must commence immediately to return the fluid under the freeboard requirements. - The tank must not have any additional wastewater added until it has sufficient capacity (i.e., is compliant). - Develop case specific action plan to prevent the overflowing and future exceedance of freeboard level. - Actions are to be agreed to with DLPE and are to be implemented.
	Flowback Storage (open and closed storages).	The combined volume of flowback storage is exceeded.	- Flowback activities to cease immediately. - Notify DLPE in accordance with the Reportable incident procedure (Section 11.1). - Develop case specific action plan to prevent the overflowing and future exceedance of freeboard level. - Actions are to be agreed to with DLPE and are to be implemented.

11. Reporting

Wastewater tracking and reporting will be completed in accordance with Section C.6.1 of the Code of Practice. Routine reporting will also be undertaken in accordance with Section 8.6.3 and Section 8.6.4 of the EMP, including annual environmental performance reporting summarising water and wastewater tracking, and separate flowback fluid and produced water reports to the Minister within 6 months of those activities occurring.

11.1. Reportable Incident Reporting

Incident reporting shall comply with the Petroleum (Environment) Regulations 2016 (the Regulations) and the *Waste Management and Pollution Control Act 1998*, where Department of Lands, Planning and Environment (DLPE) must be notified of a reportable incident as soon as practicable but no later than two-hours after the first occurrence. A reportable incident being an incident arising from a regulated activity that has caused, or has the potential to cause, material environmental harm or serious environmental harm as defined under the *Petroleum Act 1984*. Any verbal report to DLPE must be followed up by a written report from the Project Manager within three days in accordance with the Regulations.

11.2. Recordable Incident Reporting

Incident reporting shall comply with the Petroleum (Environment) Regulations 2016 (the Regulations) and the *Waste Management and Pollution Control Act 1998*, where DLPE must be notified of a recordable incident as soon as practicable but no later than 15 days after the reporting period (agreed period or each 90 day period after the day on which the EMP is approved).

A recordable incident being an incident arising from a regulated activity that:

- I. Has resulted in an environmental impact or environmental risk not specified in the current plan for the activity; or
- II. Has resulted in a contravention of an environmental performance standard specified in the current plan for the activity; or
- III. Is inconsistent with an environmental outcome specified in the current plan for the activity; and IV.
- IV. Is not a reportable incident.

12. Wastewater Risk Assessment

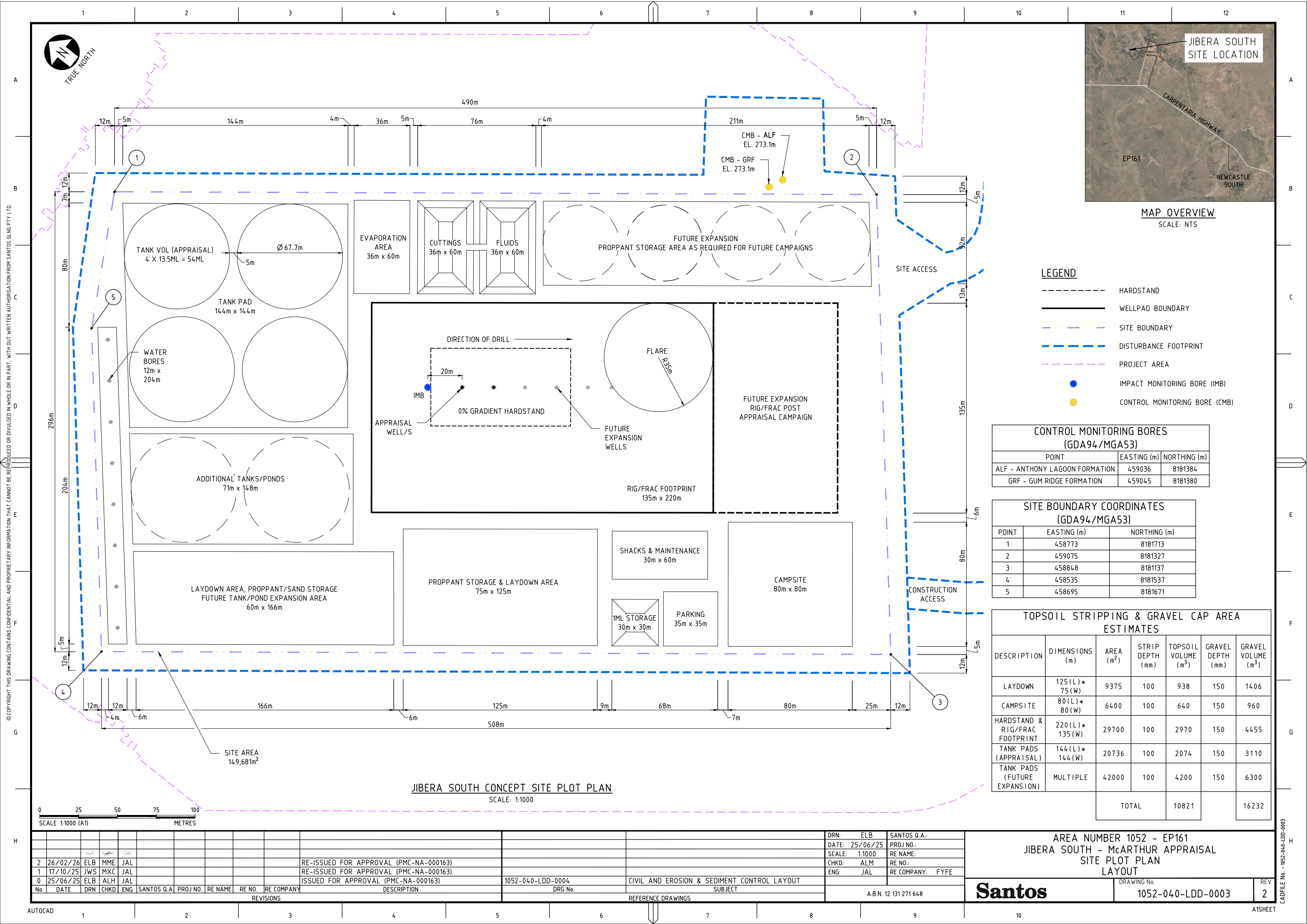
The risks associated with wastewater and flowback management are covered in the risk assessment (Appendix O of the EMP), the *Well Operations Management Plan* (WOMP) and the *Chemical Risk Assessment* (Appendix D of the EMP). Detailed assessments of the risk associated with the drilling fluids and muds was completed as part of this Chemical Risk Assessment (EMS Support, 2025).

13. References

- ANZECC. (2000, October). Australian and New Zealand Guidelines for Fresh and Marine Water Quality . Australian and New Zealand Environment and Conservation Council.
- ANZG. (2018). Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Available at www.waterquality.gov.au/anz-guidelines.
- ANZG. (2018). Default Guideline Values. Retrieved Sept 14, 2020, from <https://www.waterquality.gov.au/anz-guidelines/guideline-values/defaultv>
- ARPANSA. (2017, Sept). Guide for radiation protection in existing exposure situations - Radiation Protection Series G-2. Retrieved from <https://www.arpansa.gov.au/guide-radiation-protection-existing-exposure-situations-australian-context>
- ARPANZA. (2021, October). National Directory for Radiation Protection (2nd Edition).
- CCME. (2025). • Canadian Council of Ministers of the Environment (CCME) Canadian Environmental Quality Guidelines (CEQGs). Retrieved 2025, from <https://ccme.ca/en/summary-table>
- Commonwealth of Australia. (2018). National Waste Policy - Less Waste, More Resources.
- CRC Care. (2011, September). Health screening levels for petroleum hydrocarbons in soil and groundwater, Part 1: Technical development document. *CRC for Contamination Assessment and Remediation of the Environment, Technical Report no. 10*.
- Dept. of Environment and Conservation (WA). (2009, June 25). Fauna notes: No. 28 Long-haired rat or plague rat. Western Australia Government.
- DES/DOR. (2021, June). Queensland Land Resource Assessment Guidelines, Volume 1: Soil and land resource assessment. Queensland Department of Environment and Science and Department of Resources.
- DNRM. (2014, July). Guideline for management of Naturally Occurring Radioactive Material (NORM) in metalliferous mines (v 1.0). Queensland Department of Natural Resources and Mines.
- Ehmann, H. a. (2011). Fact Sheet - WILKINTI OR DUSKY HOPPING MOUSE *Notomys fuscus* and OOARRI OR FAWN HOPPING MOUSE *Notomys cervinus*. Government of South Australia.
- EHS Support. (2024, August 20). Tanumbirini Infiltration Modelling (HYDRUS) Results.
- EHS Support. (2025, June 2). – McArthur Appraisal Hydraulic Fracturing Fluid System, Drilling Fluid and Cementing Chemicals - Chemical Risk Assessment.
- EMS Support. (2025). *Beetaloo McArthur Basin Hydraulic Fracturing Fluid System and New Drilling Fluid and Cementing Chemicals - Chemical Risk Assessment*.
- Hazelton, P. a. (2010). *Interpreting Soil Test Results - What do all the numbers mean? (2nd edition)*. Collingwood, VIC: CSIRO Publishing.
- NEPC. (2013, April 11). National Environment Protection (Assessment of Site Contamination) Measure 1999. National Environment Protection Council.
- NHMRC. (2025, June). Australian Drinking Water Guidelines 6, 2011, v. 4.0 Updated June 2025.
- Northern Territory Government. (2025). *Code of Practice: Onshore Petroleum Activities in the Northern Territory*. Darwin: Northern Territory Government.
- NSW Agriculture. (2000). Understanding Soil pH (leaflet no. 2).
- NT Government. (2024, July). Radiation Protection Regulations 2007.
- Origin Energy. (2021, July 20). Technical Memorandum - Ramyard MWP Pilot Pond Vegetation Survey.

- Queensland Government. (2011). Salinity Management Handbook, Second Edition.
- Queensland Government. (2022, February 11). SALF2 - Salinity, soil, water, irrigation and plant salt tolerance calculator (version 2.2.2a).
- Santos QNT Pty Ltd. (2019). *Wastewater Management Plan: McArthur Basin Hydraulic Fracture Program NT Exploration Permit (EP) 161* .
- Standards Australia. (2005). AS 4482.1–2005: Guide to the investigation and sampling of sites with potentially contaminated soil – Non-volatile and semi-volatile compounds.
- USEPA. (2025). Ecological Soil Screening Levels. Retrieved 2025, from <https://www.epa.gov/chemical-research/ecological-soil-screening-level>
- USEPA. (2025). Regional Screening Levels. Retrieved 2025, from <https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables>
- WA Government. (2025, July 1). Radiation Safety (General) Regulations 1983 (WA).
- WRM Water + Environment. (2025). *Beetaloo Basin well site flood planning investigations – Jibera South project area*.
- WRM Water + Environment. (2025). *Beetaloo Basin well site flood planning investigations - Newcastle South project area*.
- WRM Water + Environment. (2025). *Design 1 in 1,000 rainfalls and freeboard - EP 161 (1413-80-B3)*. Brisbane: WRM Water + Environment.

Appendix A – Well Pad Layout Figures



Appendix B – Climate Assessment

MEMORANDUM

Date	1 July 2025
Attention	Ben Lippett – Senior Environmental Advisor - NT
Company	Santos
WRM ref.	1413-80-B3
From	Michael Batchelor – Senior Principal Engineer
Subject	Design 1 in 1,000 rainfalls and freeboard - EP161

1 BACKGROUND

Santos is preparing an Environmental Management Plan (EMP) for its proposed Northern Territory operations located in EP161. The location of EP161 is shown in Figure 1.

Santos has requested WRM to assess local rainfall characteristics to support the setting of freeboard requirements in the associated Water Management Plan in accordance with the *Code of Practice: Onshore Petroleum Activities in the Northern Territory* (the Code).

2 CODE OF PRACTICE REQUIREMENTS

The Code requires interest holders to manage the risk of overtopping from wastewater vessels by providing sufficient freeboard to accommodate inflows from rainfall for the period that the treatment infrastructure contains wastewater.

Section 7.1 of the Code lists mandatory requirements for EMPs relating to the storage of wastewater, and states that:

An EMP for a petroleum activity must include a wastewater management plan (WWMP).

The WWMP must include a description of the activities that will generate waste and wastewater, including any activities that may generate drilling materials (refer to definition in Section C.4.1), produced water, flowback fluid and any other waste which is proposed to be handled, stored or transported away from the area in which the activity is approved to be carried out, specifically including:

....

v. Estimates for the 1 in 1000 average recurrence interval (ARI) rainfall rate using Australian Rainfall & Runoff methodologies for the critical period during which there would be greatest risk of overtopping of any structures holding wastewater which are not enclosed.

...

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 ALARP and acceptable and must:

ii. Include a plan to transfer produced water and flowback fluid into above-ground enclosed tanks (see section C.4.2.2) 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 average recurrence interval rainfall estimates, as determined in C.7.1 (c) v.) for the period that treatment infrastructure contains wastewater;

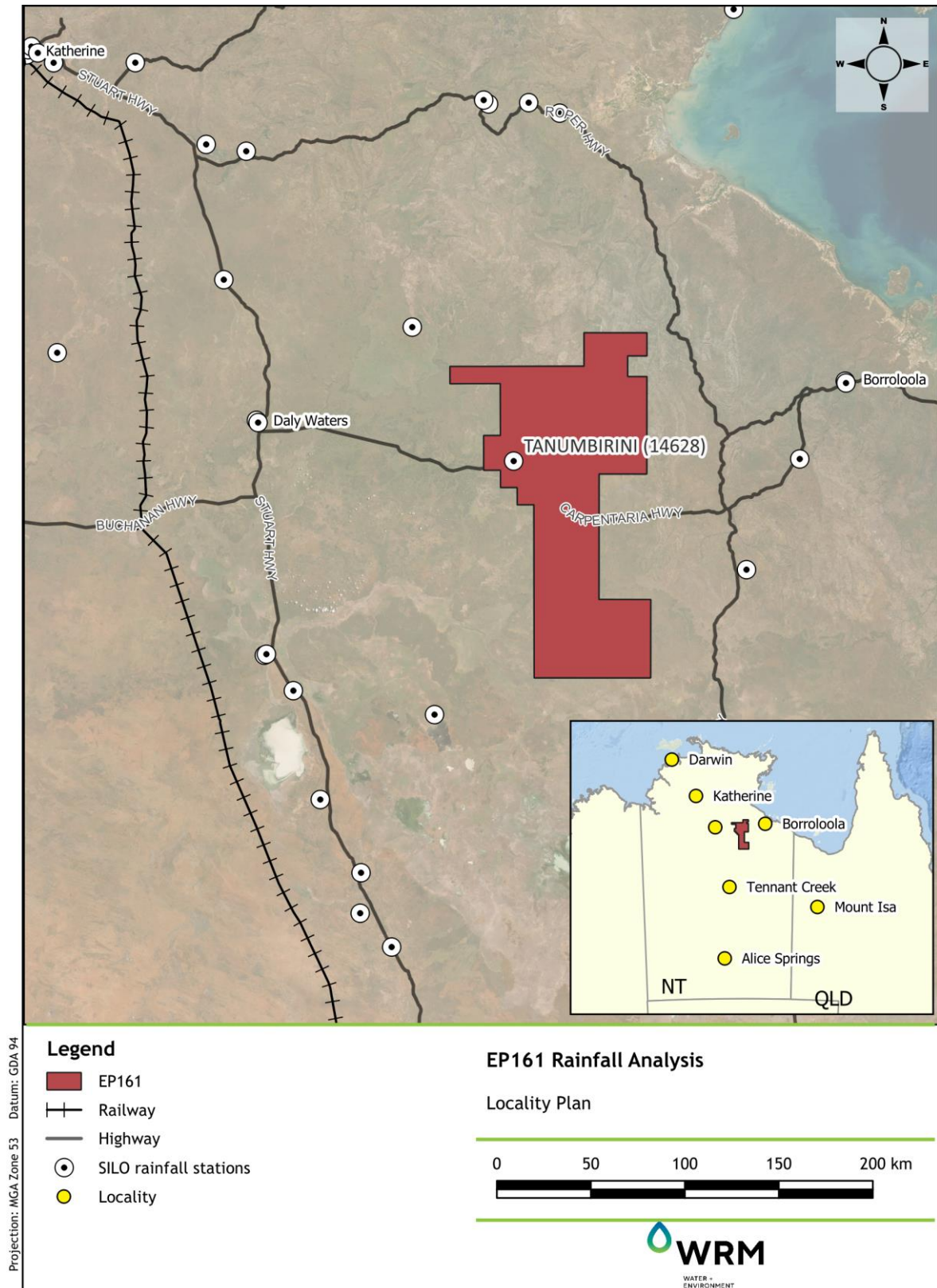


Figure 1 Locality plan – EP161

3 ADOPTED METHODOLOGY

Australian Rainfall and Runoff (ARR) (Ball et al, 2019) is a national guideline published by the Commonwealth of Australia, focussed on the estimation of design flood characteristics. The most recent update of ARR was undertaken in 2019 and includes updated guidance on design rainfalls following a review undertaken by the Bureau of Meteorology in 2016 (BOM, 2016).

Via its website (<http://www.bom.gov.au/water/designRainfalls/revise-ifd/>), the BOM provides rainfall intensity frequency duration (IFD) estimates up to the 1 in 2,000 Annual Exceedance Probability (AEP) for durations up to 7 days – which is the longest duration of interest for most catchment flood studies. ARR does not provide specific guidance for estimating design wet season rainfall totals.

The methodologies used to derive the design rainfalls are described in ARR Book 2 Chapter 3 and in various papers published by the BOM IFD revision team (Green et al, 2016). The BOM adopted the “index flood” approach to regionalising probability distribution characteristics from multiple rainfall stations. Data was pooled (after scaling by the mean of the Annual Maxima Series (AMS)) using “regions of influence” so that at each station location, parameters for estimating design rainfalls rarer than 2% AEP were based on weighted averages from stations with a minimum of 2,000 station years of record (500 years for more frequent AEPs).

Development of the BOM IFDs was a significant task, requiring access to the Bureau’s quality-controlled rainfall datasets and specialist knowledge and tools to undertake the regionalisation analysis. In the absence of these datasets and tools, the following methodology (consistent with ARR) was used to estimate the 1 in 1,000 AEP rainfall from a rainfall record:

1. Obtain the long-term quality-controlled rainfall dataset for the location.
2. Select the duration of the critical period, which is the period over which total accumulation of net rainfall is assessed. ANCOLD (2016) also suggests the critical wet period should be based on the period over which 70% of annual rainfall occurs on average. For this study a 3-month (90 day) critical rainfall period has been adopted for wet season rainfall.
3. Calculate daily rolling totals for the duration of the critical period.
4. Extract the maximum critical period rainfall total in each water year (for this project, a July to June water year was adopted) to generate an annual maxima series (AMS).
5. Sort and plot the AMS and remove low outliers which could unrealistically impact the fitted distribution.
6. Fit the GEV probability distribution to the annual maxima series using LH-moments (Wang, 1997) (with an LH moment shift of 2).
7. Using the fitted distribution, extract the 1 in 1,000 AEP rainfall depth.

4 RAINFALL DATA

In the Northern Territory, long-term rainfall recording stations are sparse and discontinuous.

The SILO Australian climate database (<https://www.longpaddock.qld.gov.au/silo/>) provides spatially and temporally complete datasets constructed from Bureau of Meteorology (BOM) records, with missing values interpolated from the raw data.

The SILO data is derived from data collected at BOM rainfall stations. The length and quality of the BOM datasets are variable, and the SILO data are carefully checked for quality, with multi-day totals disaggregated. In periods of missing data, the original BOM records are infilled with interpolated data by kriging and splining of data collected at the other stations. These “patched point data sets” can be obtained from the SILO web service for the period 1 January 1889 to yesterday.

The SILO dataset for the Tanumbirini (14628) rainfall gauge, which is located within EP161 (as shown in Figure 1) was adopted for this analysis. The data spans the period 1 January 1889 to 18 June 2025 and was downloaded on 20 June 2025 (collection of actual rainfall data at this gauge commenced in 1973). Annual rainfall totals are shown in Figure 2 and average monthly rainfalls are shown in Figure 3.

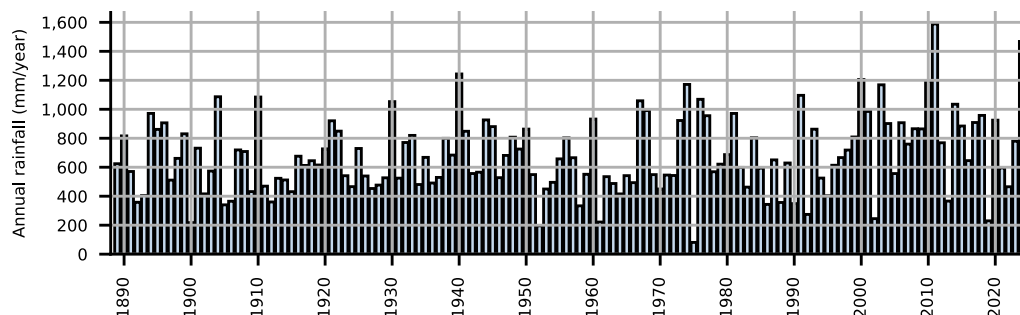


Figure 2 SILO annual rainfall totals - 1889 to 2024 – Tanumbirini (14628)

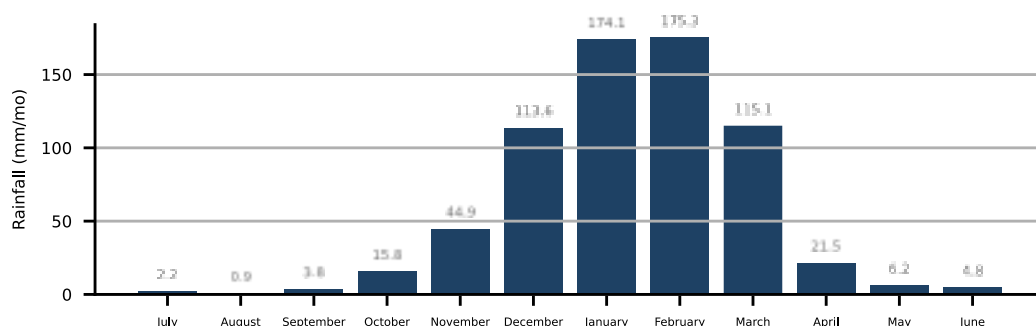


Figure 3 Average monthly SILO rainfall - 1889 to 2024 – Tanumbirini (14628)

5 RAINFALL ANALYSIS RESULTS

5.1 WET SEASON RAINFALL

Figure 4 shows the AMS of 90-day rainfalls derived from the SILO rainfall dataset for the Tanumbirini (14628) rainfall station.

Figure 5 shows the GEV fitted to the 90-day rainfall totals using LH2 moments.

The resultant 1 in 1,000 AEP 90-day critical period rainfall total for use in calculating wet season freeboard is 1,425 mm.

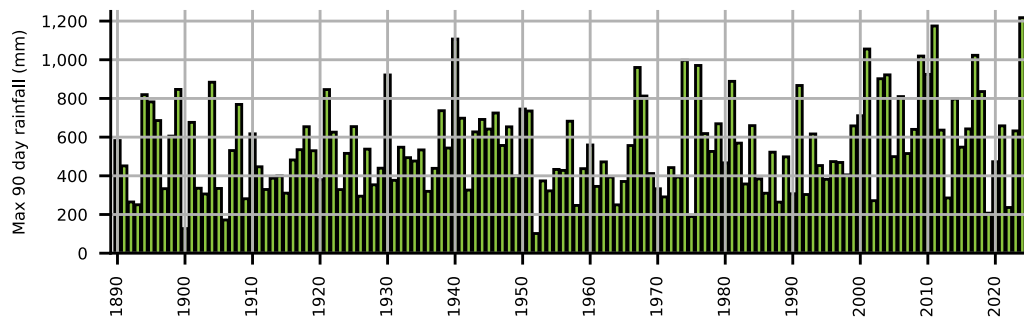


Figure 4 Maximum 90-day SILO rainfall – 1889/1890 to 2024/2025 – Tanumbirini (14628)

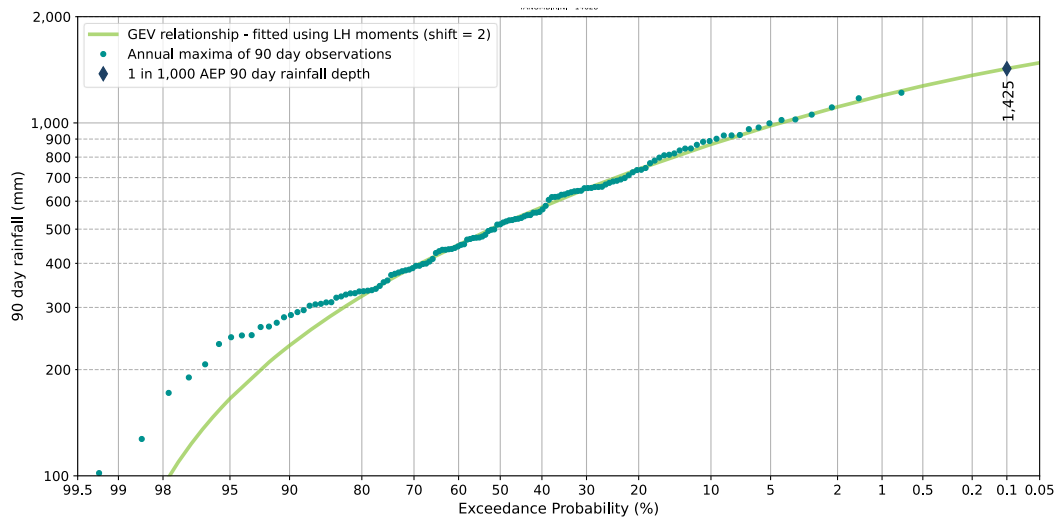


Figure 5 Generalised Extreme Value distribution fitted to ranked 90-day annual rainfall – Tanumbirini (14628)

5.2 DRY SEASON RAINFALL

Figure 6 shows the AMS of May to September dry season rainfalls derived from the SILO rainfall dataset for the Tanumbirini (14628) rainfall station.

Figure 7 shows the GEV fitted to the dry-season rainfall totals using LH2 moments.

The resultant 1 in 1,000 AEP dry season rainfall total for use in calculating dry season freeboard is 300 mm.

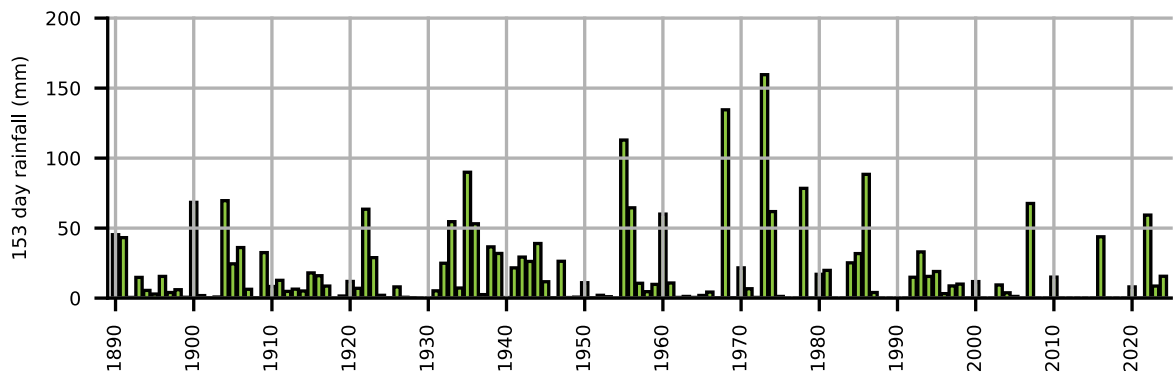


Figure 6 Annual dry season SILO rainfall – 1889 to 2024 – Tanumbirini (14628)

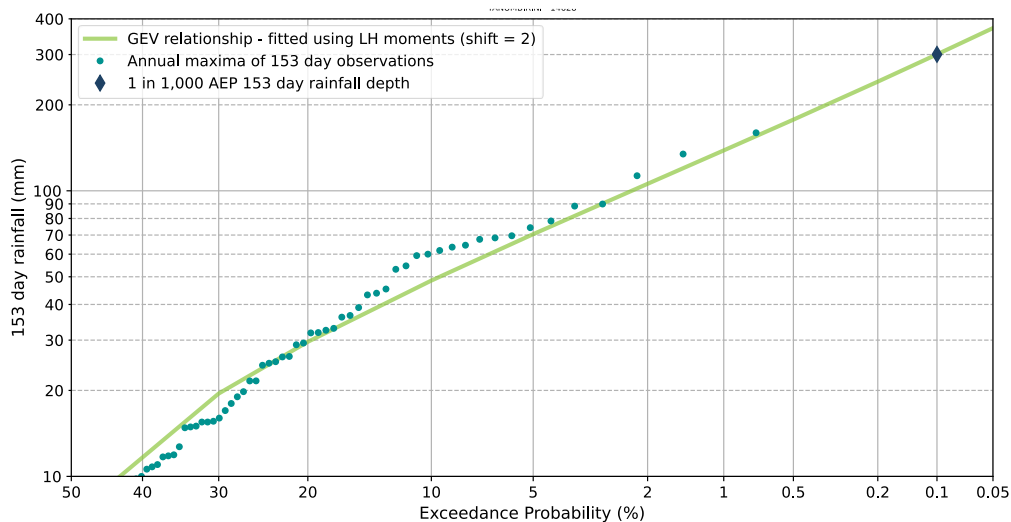


Figure 7 Generalised Extreme Value distribution fitted to ranked dry-season annual rainfall – Tanumbirini (14628)

5.3 SIGNIFICANT RAINFALL

A rainfall depth of 315 mm has been adopted for the purpose of defining a significant rainfall event under C.7.1.1 (a) ii. As shown in Figure 8, this rainfall depth exceeds the 5% AEP 72 hour BOM design rainfall depth at all locations in EP161.

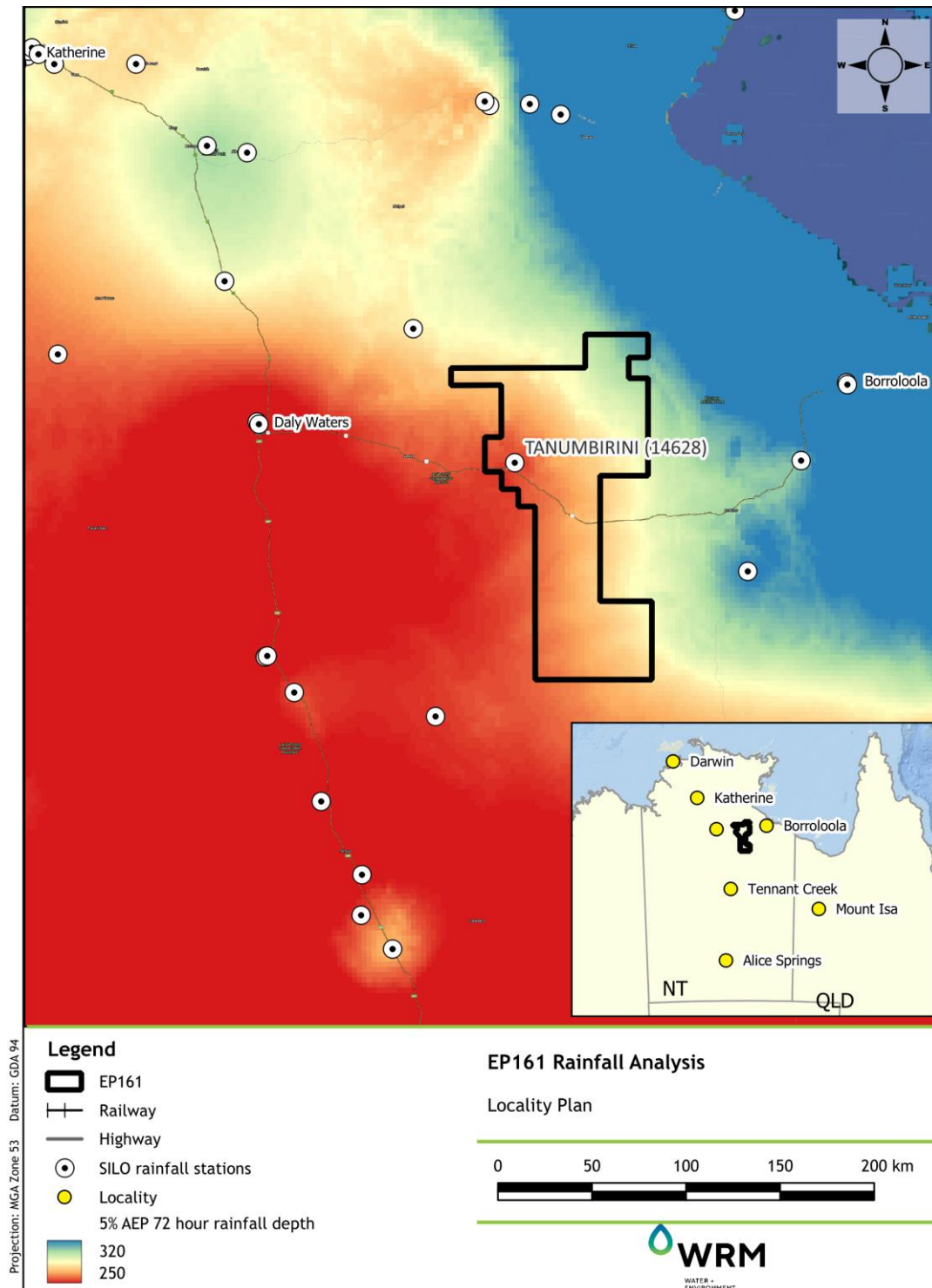


Figure 8 5% AEP 72 hour BOM design rainfall depth

6 MINIMUM FREEBOARD REQUIREMENT

The effect of evaporation co-incident with the 1 in 1,000 AEP 90-day rainfall will reduce the freeboard required to avoid overtopping of a containment structure. The freeboard is estimated as:

Freeboard = 1 in 1,000 AEP wet season rainfall - coincident evaporation estimate

Evaporation is significantly reduced during periods of extreme rainfall. For the purpose of freeboard calculation, the co-incident wet-season evaporation was estimated using the minimum 90-day SILO Morton's Lake evaporation at the Tanumbirini rainfall station site (325 mm in 1987).

The minimum wet season freeboard requirement for EP161 is:

$$1,425 \text{ mm} - 325 \text{ mm} = 1,100 \text{ mm}$$

The estimated 1 in 1,000 AEP dry season rainfall is relatively small compared to design event rainfalls. A **dry season freeboard of 500 mm** is recommended, which is greater than the 1 in 1,000 AEP 72 hour rainfall at all locations in EP161.

7 REFERENCES

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|---------------------|---|
| Ball et al, 2019 | <i>Australian Rainfall and Runoff: A Guide to Flood Estimation</i> , Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors), Commonwealth of Australia, 2019 |
| BoM, 2016 | <i>New Design Rainfall Intensity Frequency Duration Estimates for Australia</i> . Australian Government Bureau of Meteorology, 2016.
http://www.bom.gov.au/water/designRainfalls/revised-ifd/ |
| DEPWS, 2019 | <i>Code of Practice: Onshore Petroleum Activities in the Northern Territory</i> , Department of Environment and Natural Resources, NT Government, 19 February 2025. |
| Green et al, 2016 | <i>Comparing CRCFORGE Estimates and the New Rare Design Rainfalls</i> Version 4, J.H. Green; C. Beesley; C. The; S. Podger and A. Frost, Bureau of Meteorology, November 2016. |
| Green et al, 2015a | <i>New Design Rainfalls for Australia</i> Green, J.H., Beesley, C., The, C., and Podger, S. Presented at Hydrology and Water Resources Symposium, Hobart, Tas, December 2015. |
| Jeffrey et al, 2001 | <i>Using spatial interpolation to construct a comprehensive archive of Australian climate data</i> , Jeffrey, S.J., Carter, J.O., Moodie, K.B. and Beswick, A.R. Environmental Modelling and Software, Vol 16/4, pp 309-330. DOI: 10.1016/S1364-8152(01)00008-1, 2001. |
| Wang, 1997 | <i>LH-moments for statistical analysis of extreme events</i> . Water Resources Research, 33(12) 2841-2848. |
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Appendix C – Contaminant Screening Methodology

1. Introduction

This section sets out the screening approach used to confirm that residual drilling material (RDM) is suitable for on-site burial under the certified burial methodology. The method is informed by a Conceptual Site Model (CSM) that identifies COPC, potentially affected media, receptors and exposure pathways relevant to the post-rehabilitation condition of the well pads. Bulk drilling fluids will be removed for reuse or off-site disposal; accordingly, the screening focuses on RDM (cuttings with residual fluids) to be buried in place. The CSM and screening outcomes will be reviewed and, where necessary, updated under the direction and oversight of a suitably qualified and competent person (SQCP) using site-specific data from the RDM sampling program.

2. Conceptual Site Model

The applicability of screening criteria is informed by the conceptual site model (CSM), which is a written and/or visual representation of a site that characterises:

- Sources or potential sources containing contaminants of potential concern (COPC).
- Affected or potentially affected environmental media (e.g. soil, groundwater, surface water).
- Relevant human and ecological receptors.
- Complete or potentially complete contaminant exposure pathways.

In the context of this WWMP, the applicable CSM is that which represents the future state of the site that will exist following the implementation of management measures for the drill waste and eventual rehabilitation of the drill pads.

Bulk drilling fluids will be collected from the drilling sumps and may be transferred to a separate wastewater tank for temporary storage. The fluids will either be reused or transported off-site for disposal and therefore are not relevant to the CSM. The remaining RDM, comprising drill cuttings and residual fluids, is proposed to be managed on site via the certified burial methodology within this WWMP. Residual fluids will be removed or evaporated as far as practicable before the sampling and analytical program commences. COPC in the RDM and exposure pathways associated with its burial therefore central to the selection of screening criteria.

The following provides a description of the CSM for Jibera South and Newcastle South, which is largely based on the CSM for the nearby Mount Brown (formerly Tanumbirini) well pad area. All three of these sites are located in a nearly identical environmental, geological and hydrogeological setting, and the drilling processes and RDM management practices that have been or will be employed at each of the sites are also nearly identical (as governed by the Code of Practice and 2025 Code of Practice: Well Integrity). These similarities make them suitable analogues for CSM development.

Minor variability between the analogues is acknowledged, but the CSM will remain fundamentally consistent. Variables between the sites can be controlled through management practices (e.g. the burial methodology will ensure a minimum depth of native cover, burial areas will be located outside of flood risk areas, compliance sampling etc.). Natural site variables relevant to the CSM may need to be confirmed, but it is not expected that there will be appreciable differences between the sites (e.g. confirming that shallow groundwater is not present, confirming that the depth to aquifers and hydrostratigraphic units are similar).

Furthermore, this Conceptual Site Model will be reviewed during future sampling and analytical programs with consideration of site-specific data that is obtained.

2.1. Contaminant Source

The RDM composition includes COPC derived from additives used in drilling fluids or geogenic sources, including rock cuttings and formation water that is returned to the surface during drilling. Note that Santos does not use any persistent, bioaccumulative and toxic (PBT) substances or petroleum hydrocarbons as additives in drilling fluids. Table C-1 lists COPC and key indicator parameters associated with the RDM. These are generally aligned with

Table 9 of the *Code of Practice* (Northern Territory Government, 2025), which identifies analytes for drilling waste assessment.

Additives used in drilling fluids include inorganic salts such as calcium chloride, ferrous sulphate, potassium hydroxide, potassium pyrophosphate, potassium silicate, sodium acid pyrophosphate, sodium carbonate, sodium chloride, sodium hydroxide and sodium silicate, which completely disassociate in aqueous media. These are used for clay stabilisation (to prevent clay swelling along the borehole wall), as weighting agents and/or for pH control. Due to the ion content of the additives, as well as ions potentially introduced through formation water, the overall salinity of RDM is the primary issue of concern.

Other chemical additives include low concentrations of organic constituents such as alcohols, alkanes, amides, citric acid, ethers, glycols, hydrotreated light petroleum distillates, sulfomethylated quebracho and tartaric acid. None of these constituents are persistent in the environment, and are either readily biodegradable, and/or are of low ecological concern. Glutaraldehyde is also commonly used in low concentrations as an antimicrobial. Although this substance presents a high level of toxicity to aquatic life in particular, it has a short half-life in the environment (10.6 hours in water/sediment systems and 1.7 days in soils) and will not persist within the RDM.

Other additives could include organic materials such as starches and xanthum gum, bentonite clay or Portland cement. These constituents are not considered to present an appreciable environmental concern and do not warrant consideration from a COPC perspective.

Contaminant sources from geogenic constituents can include various metals and soluble ions contained in rock cuttings and formation water. Low levels of radionuclides associated with shales and hydrocarbons associated with the organic rich Velkerri and Kyalla shale formations may also be present. However, previous results from Mount Brown show that human health and environmental risk can be reduced to ALARP through placement of an appropriate level of native soil cover (i.e., 1.5 m).

Table C-1: Constituents of potential concern associated with residual drilling materials

Constituent	Indicator	Basis
Metals	Al, As, Ba, Be, B, Cd, Co, Cr, Cu, Pb, Mn, Hg, Mo, Ni, Se, Ag, Sr, V, Zn	These are key metals that could be geogenically derived from cuttings or formation water.
Cations and anions	Salinity - measured as electrical conductivity (EC) or total dissolved solids (TDS)	- EC and TDS are indicator parameters for salinity and overall ion content of the drill fluids. - Major cations and anions contained in drill fluid additives (Ca, Mg, K, Na, Cl, SO₄, N, P) are likely to contribute to the bulk of the salinity. Of these, only Cl warrants separate consideration as a COPC. Drill cuttings and formation water may also contribute some proportion of ions, but the bulk of the ion content is expected to be derived from drill fluid additives.
	Cl	Potentially a major ion in drill fluids and formation water that presents a potential risk to plant growth.
	F	Fluoride is a minor, geogenically derived ion.
	pH	The RDM tends to be slightly to moderately alkaline, and therefore consideration of pH is warranted.
Hydrocarbons	Total petroleum hydrocarbons (TPH) / total recoverable hydrocarbons (TRH)	Low concentrations of hydrocarbons could be present in drill fluid additives, or geogenically derived.
	Benzene, toluene, ethylbenzene, xylenes (BTEX)	BTEX constituents are not likely to be present, but are proposed to be treated as COPC due to the potential presence of hydrocarbons.

	Polycyclic aromatic hydrocarbons (PAH - as listed in the CoP)	PAH constituents are not likely to be present, but are proposed to be treated as COPC due to the potential presence of hydrocarbons. Although phenanthrene was detected in two RDM samples from Tanumbirini, these may be anomalous results.
Naturally occurring radioactive materials	Gross alpha and beta activity	Low levels of radionuclides are expected, but should be confirmed due to association with shales.

2.2. Review of potentially affected media

2.2.1. Soils

With implementation of the proposed burial methodology, the RDM body itself will form an unconsolidated soil-like material, that from a contaminant risk and screening perspective can be assessed as soil. Leaching of contaminants from the RDM could also potentially impact underlying soils. However, the underlying geology at Jibera South and Newcastle South is expected to comprise sequences of low permeability claystone, siltstone and sandstone, which would limit the potential for infiltration of water and leached contaminants. Additionally, even if the soils beneath the RDM were to be affected, the shallower RDM itself would remain the primary media of concern with respect to soil exposures. Soils overlying the buried RDM, which will comprise native soils, are unlikely to be impacted.

2.2.2. Groundwater

The offset site (Mount Brown) is anticipated to have a similar geological and hydrogeological profile as the Jibera South and Newcastle South sites, which have also been reviewed against recently completed 2D seismic data. The uppermost aquifers at the sites are part of the Cambrian Limestone Aquifer (CLA) system, which are hosted in either the Anthony Lagoon Beds or Gum Ridge Formation. These hydrostratigraphic units are overlain by Cretaceous strata comprising low-permeability claystone, siltstone and sandstone sequences. At Mount Brown, the total thickness of this strata is approximately 50 metres, and at Jibera South and Newcastle South the thickness is likely in the order of 90 metres or greater.

Infiltration modelling was conducted for Mount Brown (EHS Support, 2024) using the Hydrus modelling software. Figure C-1 shows the dimensional conceptualisation of each of these sequences beneath the Mount Brown Site that was used for the model, which comprise Cretaceous claystone, siltstone and sandstone sequences.

Table C-2 and

Table C-3 summarise the hydraulic conductivity values used for the model and individual modelling scenarios.

The results from the modelling showed that there was negligible vertical groundwater flux below approximately 6 m in depth within the Cretaceous claystone, siltstone and sandstone sequences, even under a high-high permeability modelling scenario commensurate with sandstone (i.e., modelling scenario B-3). Figure C-2 shows the water flux through select observation points (or nodes) in the soil profile over time for this scenario. The model for the high-high scenario predicted that the wetting front would begin to occur at a depth of 5.0 metres and 5.6 metres after approximately 2,300 days (six years) and 4,000 days (11 years), but does not reach a depth of 6.2 metres within 10,000 days (27 years – the maximum timeframe supported by the model software). The model predicted that there was virtually no water flux at a depth of 6.2 metres, with flux values remaining at less than -1.4×10^{-8} m/day, respectively. Below this depth, the model predicted that water flux would be less than -6.6×10^{-12} m/day.

The modelling results demonstrate that the presence of this strata (the Cretaceous strata in particular) would effectively preclude the potential for appreciable seepage of COPC from the buried RDM into the underlying regional CLA system.

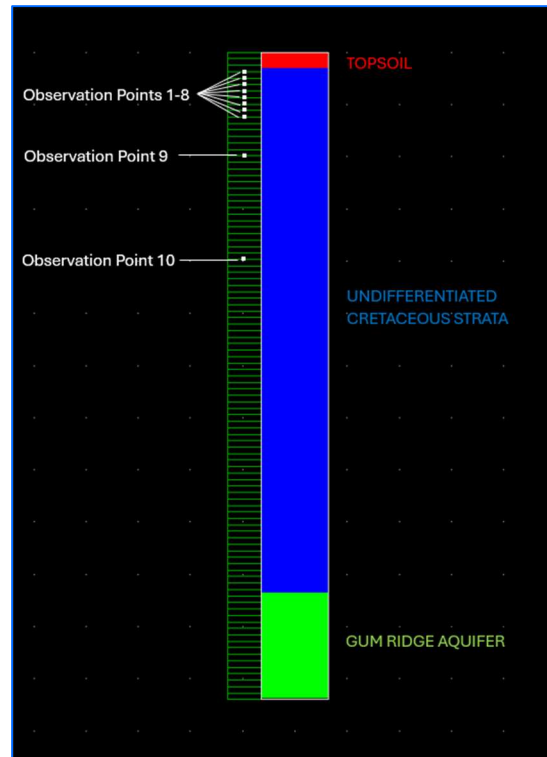


Figure C-1: Dimensional Conceptualisation of Strata Beneath the Mount Brown Site

Table C-2: Estimated Hydraulic Conductivity Values

Unit Name	Hydraulic Conductivity Range (m/day)	Source
Soil	10^{-4} to 10^0	Freeze and Cherry (1979) –values for silt/loess materials
Undifferentiated Cretaceous Strata	10^{-8} to 10^{-5}	Smith, et al (2016)
Gum Ridge Aquifer	10^{-2} to 10^3	Freeze and Cherry (1979) –values for karst limestone

Table C-3: Hydraulic Conductivity Values Used for Model Iterations

EMP Material	Scenario	K (m/d)
Soil	A - normal case	2.5E-01
	B - high case	2.5E+00
Undifferentiated Cretaceous Strata	1 - normal case	1.0E-05
	2 - high case	1.0E-04
	3 - high high case	1.0E-02
Gum Ridge limestone	All	3.5E+00

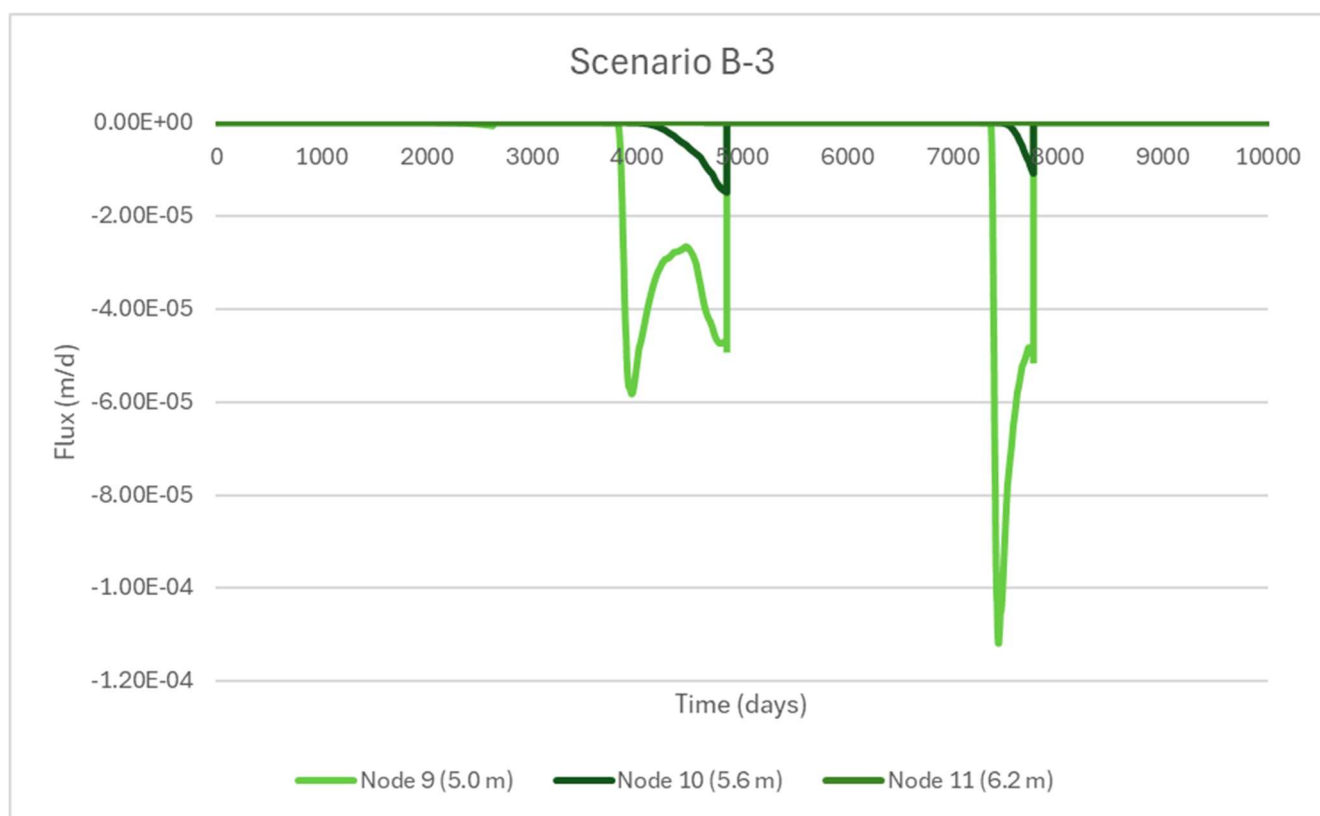


Figure C-2: Flux Through Observation Nodes Over Time (Modelling Scenario B-3)

Drilling of exploration wells or groundwater bores at Jibera South and Newcastle South will provide accurate geological information for the site, which can be used to confirm that the total thickness of the Cretaceous strata is on the order of 50 metres or greater. The potential for groundwater within the CLA system to be impacted by leaching from the RDM will be considered negligible if there is a significant thickness (e.g. >6 m) of claystone and/or siltstone sequences within the Cretaceous strata.

Additionally, it is not anticipated that shallow groundwater-bearing zones will be present within the Cretaceous strata itself, and therefore groundwater within this unit is unlikely to be affected.

Notwithstanding, the potential for the presence of shallow groundwater within the Cretaceous strata will be assessed for Jibera South and Newcastle South to confirm whether this is the case. In addition, the validity of the infiltration model will be reviewed and confirmed for the specific sites where RDM burial is proposed to be undertaken, and the model will otherwise be updated based on site-specific lithology and hydrostratigraphy. There will be sufficient time following the drilling of exploration wells or groundwater bores to review the geological information and confirm the lack of groundwater bearing units prior to implementing the burial method.

2.2.3. Surface Water

There are two potential mechanisms for surface water impacts that warrant consideration, neither of which is likely to be plausible.

The first is the potential for impacted shallow groundwater near the RDM burial area to discharge to surface water via lateral groundwater flow. This would require the presence of a shallow, contiguous groundwater-bearing zone that is capable of sufficient lateral flow to intersect a nearby stream. However, as discussed in Section 4, implementation of the RDM burial methodology will be preceded by confirmation that no such groundwater-bearing zones present. Therefore, this mechanism for contaminant transport can be ruled out.

A second potential mechanism is for surface water to become directly impacted via encroachment of surface water into the burial areas as a result of flooding events or stream channel migration. In this case, impacts to surface water would require both encroachment into the RDM area *and* scouring of the cover material to an extent that the RDM is directly exposed to the surface water. However, the RDM burial methodology will as far as reasonably practicable ensure that the RDM burial areas are located outside of any 1 in 100 annual exceedance probability (AEP) events for flood risk, which would effectively preclude the risk that the RDM burial areas would be subject to scouring from stream channel flow. In addition, the RDM will be buried at a minimum depth of 1.5 metres on generally flat terrain, which further limits the risk that flood encroachment or scouring would directly expose the RDM to surface waters.

2.2.4. Potential human and ecological receptors

EP 161 is in a remote, sparsely populated region with limited development. The primary commercial activities in the region include pastoral activities and shale gas exploration and development. Recreational activities associated with tourism may also be present, but would largely be confined to travel along major roads and public access tracks. The Jibera South and Newcastle South drill pads are both away from the main transportation corridor, the Carpentaria Highway, and to reach the sites requires travel along several kilometres of private access tracks. The sites are not easily accessible by the public.

The dominant long-term land use in the region will remain pastoral in nature (i.e., mainly used for cattle grazing), which will be interspersed with gas exploration and development activities. Appreciable recreational use in proximity to the well pads is unlikely to occur, although potentially the landholder or guests could occasionally use the areas for recreational purposes (e.g. hiking and camping). Water supply bores identified are greater than three kilometres from the sites, and are installed in the CLA system, which would not be affected by leaching from the RDM. Therefore, groundwater users in the area are not considered potential receptors (subject to confirmation of Cretaceous claystone, siltstone and sandstone sequences overlying the CLA in the respective areas). Due to the absence of sustained surface water features (i.e., streams in the area are ephemeral), it is assumed that there is no recreational use of surface water.

Given the future land use, it is anticipated that the key rehabilitation requirements for the well pads will include reinstatement and stabilisation of the landform and soils, and re-establishment of self-sustaining pasture species, principally grasses, similar to the vegetation communities in the surrounds. Incidental growth of woody vegetation may also occur, which in the proposed drill pad areas and surrounds currently comprises scattered shrubs and trees. It is not anticipated that regrowth of woody vegetation within the limited extent of the proposed burial areas will be required to meet the overall rehabilitation requirements for the greater well pad areas.

The primary rooting zone for crops and grasses is assumed to be the upper 0.15 metres, which is consistent with the depth used to calculate cumulative contaminant loading limits (CCL) for irrigation (Australian and New Zealand Guidelines [ANZG], 2018). Although some species could extend roots to greater depths, even in these instances the bulk of the root zone structure would be near surface, which is where plants derive the bulk of their water (DERM, 2011) (Australian and New Zealand Guidelines [ANZG], 2018). The expected absence of shallow groundwater, and the fact that pasture species die off during the dry winter season further suggests that pasture species would not derive a significant component of water from deep within the soil column, or otherwise from a permanent groundwater source, which often drives deeper root penetration. Rather, the bulk of the water supply would come from near surface during rainfall events, which is also where the bulk of the root zone structure would be located.

Based on the current and future land uses, potential human receptors to be considered include gas field workers, agricultural maintenance workers performing intrusive work (e.g. post setting), general agricultural workers (farmers) and open-space recreational users (adult/child).

Potential ecological receptors include biota supporting ecological processes (including micro-organisms and soil invertebrates), flora (pasture species, shrubs and trees) and fauna (grazing animals, rodents, avian species). It is assumed that there are no aquatic receptors due to the absence of surface water in the vicinity of the areas.

2.2.5. Potentially complete exposure pathways

The following provides a description of potentially complete exposure pathways associated with COPCs contained within buried RDM (i.e., RDM buried in accordance with an approved burial methodology). Table C-4 provides a summary of potentially affected media, potential receptors and potentially complete exposure pathways with the proposed burial methodology in place, which informs the potential screening criteria that will apply to the RDM.

The proposed burial method will require the placement of at least 1.5 metres of native soils over the RDM. This will create a barrier to direct contact and incidental ingestion exposure pathways for grazing mammals (including cattle), avian species, soil invertebrates and burrowing mammals. In addition, this depth of cover would preclude or significantly limit the potential for exposures to with burrowing organisms. Most biota and biological activity in soils occurs within the upper 0.6 metres of the soil profile (Anderson et al, 2010), and depths significantly beyond this are not considered biologically relevant in the context of direct contact and ingestion exposures for soil invertebrates. Further, depths for burrowing mammals typically range from surficial (i.e., within cracks in the soil) to depths of between 1 and 1.5 metres, depending on soil conditions and species. For example, deeper burrowing organisms such as the dusky hopping mouse and the long haired rat can construct complex tunnel systems reaching depths of up to 1.0 metres (in soft sandy habitats) and 0.8 metres in depth, respectively (Ehmann, 2011) (Dept. of Environment and Conservation (WA), 2009) (Predavec and Dickman, 1994). Given the proposed burial depth of the RDM >1.5 metres, there are no complete exposure pathways for soil invertebrates, burrowing mammals, grazing mammals and avian species.

The proposed burial depth of 1.5 metres is also below the primary root zone of most pasture species, and therefore COPC at this depth, including salts, are not likely to affect plant growth, or otherwise subject to plant uptake and secondary exposure to grazing mammals.

Without controls, potential human health exposure pathways within the vicinity of the well sites would typically include incidental ingestion and dermal contact with surface soils and inhalation of surface soil-derived particulates and vapours. In addition, low-density agricultural workers could come into contact with slightly deeper soils during agricultural activities like ploughing, which would typically disturb soils up to depths of 0.3 metres and agricultural maintenance workers could potentially come into contact with soils at a depth of 0.75 metres during intrusive activities like post setting. After placement of the RDM and native soil cover, the RDM will be at a depth greater than what would be encountered by casual occupants or future workers at the sites. Therefore, incidental ingestion of soils, dermal contact with soils and inhalation of soils particulates are considered to be incomplete exposure pathways for human receptors.

Although it is not anticipated that the RDM will contain appreciable concentrations of volatile organic contaminants (VOCs), theoretically inhalation of VOCs is considered a potentially complete exposure pathway that warrants screening. However, the depth of burial will significantly limit the potential risk associated with migration of VOCs. Similarly, although the radiological activity from the presence of NORM in the RDM is generally low, external exposure to radiological activity from NORM is considered a potentially complete exposure pathway for low-density agricultural workers and agricultural maintenance workers (or casual users of the site, if present). However, soil provides effective shielding from radiation, and the depth of burial (combined with the expected low activity concentrations in the RDM based on the RDM analysis results from Mount Brown) will significantly limit the potential risks associated with radiological emissions.

Based on the anticipated depth to groundwater and thickness of overlying low-permeability strata, and the distance to surface water features, it is unlikely that contaminant exposure pathways related to groundwater or surface water would be complete at the Jibera South and Newcastle South sites. The groundwater exposure pathways at these sites would be considered incomplete and would not warrant further consideration if it is confirmed that:

- The total thickness of claystone/siltstone/sandstone exceeds 50 metres in thickness; or
- Siltstone/claystone sequences exceed 12 metres in total thickness overlying any relevant aquifer or groundwater-bearing stratigraphy (this allows for a safety margin of 100 per cent based on the <6 metre depth at which the modelling predicts negligible vertical water flux).

If these attributes cannot be confirmed, then potentially complete exposure pathways that require further consideration could include ingestion of groundwater (brought to the surface through water bores) by human receptors and cattle.

Table C-4: Summary of potentially affected media, potential receptors and potentially complete exposure pathways with burial methodology in place

Potentially Affected Media		Potentially Relevant Receptors	Complete or potentially complete contaminant exposure pathways with burial methodology in place*		
Media Considered	Applicable?		Direct Contact	Ingestion / Uptake	Volatilisation or Radiological Emissions
Soils					
Buried RDM and soils underlying buried RDM	Yes.	Workers conducting intrusive works (agricultural or gas field)	N	N	Y
		Casual site users (visitors, recreational users)	N	N	Y
		Grazing animals and avian species	N	N	Y
		Burrowing organisms	N	N	Y
		Vegetation	N / A	N	N / A
Groundwater					
Shallow groundwater in Cretaceous strata	Unlikely - not applicable if it is confirmed that shallow groundwater is not present, or overlying Cretaceous strata reduces infiltration potential to negligible levels.	Groundwater dependent vegetation	N	N	N
		Aquatic ecological receptors	N	N	N
CLA aquifer	Unlikely - not applicable if overlying low permeability cretaceous strata confirmed.	Groundwater bore users (humans and livestock)	N	N	N
Surface water					
Ephemeral surface water	Unlikely - not applicable if assessment confirms shallow groundwater is not present, or groundwater does not discharge to surface water, and confirmation that buried RDM is outside of area subject to frequent flooding.	Aquatic ecological receptors	N	N	N
*Key controls for burial methodology include: - RDM burial depth >1.5 m with a least 1.5 m of native soil cover placed over the RDM. - RDM burial area located outside of 1:100 annual probability exceedance event for flooding. - Confirmation that there is >50 m of Cretaceous strata (comprising claystone, siltstone and sandstone sequences) overlying local Cambrian Limestone Aquifer (CLA) systems. - Confirmation that shallow groundwater is not present within Cretaceous strata, and/or is at sufficient depth beneath Cretaceous strata that water infiltration is negligible.					

2.3. Adopted Guideline Values

The contaminant screening methodology considers guideline values from a number of jurisdictions, which apply to various exposure scenarios for relevant COPC. However, natural site conditions (e.g. depth to groundwater, low permeability stratigraphy), and the implementation of the burial methodology itself will effectively eliminate most potential exposure pathways. These factors will need to be taken into consideration when applying the screening criteria to the RDM. Further, the chemical risk framework for drilling fluids ensures that potential environmental risks associated with drilling chemicals are assessed and understood, and that high-risk chemicals are not used. This provides an additional level of assurance in regard to the potential COPC that may be present in drilling fluids.

The screening criteria are based on a hierarchy of relevant NT, Commonwealth, other State and international guidelines. In the context of the NT, the contaminated land guidance (*NT Contaminated Land Guideline*; NTEPA, 2017) references the NEPM, which provides the majority of screening criteria for this risk assessment. Relevant and applicable national and international screening criteria were selected based on the receptors and potentially complete exposure pathways identified in the CSM. Table C-5 provides a summary of relevant screening criteria for COPC and their applicability with the burial methodology in place. Table C-6 provides adopted screening criteria for specific COPC.

Although there are a number of exposure pathways that are incomplete with respect to some of the COPC, analysis will be undertaken for all identified COPC (as per Table 9 of the CoP). These results will be compared against applicable Tier 1 screening levels as an additional line of evidence to inform whether the on-site burial of RDM will present a risk of environmental harm. When comparing RDM analytical results to adopted criteria, if a criterion is exceeded but the relevant pathway is absent, the exceedance will be documented, but it will not be considered to represent a risk under the proposed burial scenario. Screening criteria have been retained in the assessment tables for completeness, but will be excluded from risk determination where pathways are absent.

The following guideline values were considered for the adoption of screening criteria based on exposure pathways that were considered potentially complete with the RDM methodology in place:

- NEPM Australian National Environmental Protection Council (NEPC) Assessment of Site Contamination Health Screening Levels (HSLs) (NEPC, 2013)
- Western Australia *Radiation Safety (General) Regulations 1983* (WA Government, 2025)
- ARPANSA *National Directory for Radiation Protection* (ARPANZA, 2021)
- *Radiation Protection Regulations 2007* (NT Government, 2024) (defers to the ARPANSA (2021) for definitions)

The following guideline values are not applicable based on exposure pathways that were considered *incomplete* with the RDM burial methodology in place:

Human health screening criteria for soils

- NEPM Australian National Environmental Protection Council (NEPC) Assessment of Site Contamination Human Health Investigation Levels (HILs) (NEPC, 2013)
- USEPA Regional Screening Levels (RSLs) for Residential Land Use (USEPA, 2025).

Ecological screening criteria for soils

- NEPM Australian National Environmental Protection Council (NEPC) Assessment of Site Contamination Ecological Investigation Levels (EILs) and Ecological Screening Levels (ESLs) (NEPC, 2013)
- Canadian Council of Ministers of the Environment (CCME), Canadian Environmental Quality Guidelines (CEQGs), Soil Screening Guidelines for Agricultural and Residential and Open Spaces (CCME, 2025)
- United States Environmental Protection Agency Ecological Soil Screening Levels (Eco-SSLs) (USEPA, 2025).

Soil Properties for Plant Growth

- Australian and New Zealand Guidelines (ANZG) for Fresh and Marine Water Quality: Volume 3 Primary Industries – Rationale and Background Information Soil Salinity Guideline (ANZECC, 2000)
- Salinity Management Handbook Plant Salt Tolerance Data (Queensland Government, 2011).

Human health (and stock health) screening criteria for groundwater

- National Health and Medical Research Council (NHMRC) Australian Drinking Water Guidelines (ADWG) (NHMRC, 2025)
- NEPM Australian National Environmental Protection Council (NEPC) Assessment of Site Contamination Groundwater Investigation Levels (GILs) for Drinking Water (HSLs) (NEPC, 2013)
- United States Environmental Protection Agency Regional Screening Levels for Protection of Groundwater (RSL PGW) (USEPA, 2025)
- Australian and New Zealand Guidelines (ANZG) for Fresh and Marine Water Quality Protection of Stock Watering (ANZECC, 2000) (ANZG, 2018).

Ecological screening criteria for groundwater

- NEPM Australian National Environmental Protection Council (NEPC) Assessment of Site Contamination Groundwater Investigation Levels (GILs) for Fresh Waters (NEPC, 2013).

Table C-5: Summary of adopted screening criteria for potentially relevant exposure pathways

Adopted Screening Criteria	Applicable COPC Screening Parameter	General Applicability	Applicability with RDM Burial Methodology in Place	Rationale for Selection
NEPM HSL for vapour intrusion, Recreational C (NEPC, 2013)	BTEXN and TRH F1 and F2 fractions w/ silica gel cleanup on F2)	Soils / RDM - surface to >4 m depth	Applicable	- The NEPM Recreational C HSLs are suitable for assessment of exposures to casual site users, who could theoretically be exposed to VOCs at surface. The NEPM Commercial / Industrial D HSLs are applicable for assessment of exposures to site workers, who could theoretically be exposed to VOCs during work activities. For screening purposes, the most conservative assumptions will be applied (sand, impact at 1 to <2 m). - For HSLs, where a contaminant is considered “not limiting” or there is no criterion, the NEPM management limits were used for TRH/TPH and the corresponding soil saturation concentration (C_{sat}) used for aromatic hydrocarbons.
NEPM HSL for vapour intrusion, Commercial / Industrial D (NEPC, 2013)				
Threshold for NORM (WA Government, 2025)	Alpha and beta activity	Soils / RDM – any depth	Applicable	- As per the <i>Radiation Safety (General) Regulations 1983 (WA)</i> natural substances with an activity of less than 30,000 Bq/kg are not considered a radioactive substance for the purposes of the Act (WA Government, 2025). This is considered an appropriate value for screening of gross alpha and beta activity concentrations in the RDM. - The Radiation Protection Regulations 2007 (NT, 2024) defers to the ARPANSA <i>National Directory for Radiation Protection</i> (2021) for definitions of radioactive material. For natural sources, material is not required to be managed as NORM unless the activity concentration of any individual radionuclide in the uranium or thorium decay chains is greater than 1 Bq/g, or the activity concentration of ^{40}K is greater than 10 Bq/g. Based on RDM samples from Mount Brown, the maximum measured activity concentration was 0.189 Bq/g for the former and 0.830 Bq/g for the latter. Therefore, it is unlikely that RDM from samples for Jibera South and Newcastle South would exceed these thresholds. In addition, ARPANSA sets a radiation dosage threshold for members of the public of 1 mSv/year, below which protective measures are unlikely to be justified. As discussed in Section 2.4.7, based on RESRAD modelling for buried RDM modelling at Mount Brown, the estimated maximum dose was after 1000 years was 0.003134 mSv per year, which is approximately 0.3% (or 300x lower) than the effective dose limit of 1 mSv/yr. On these bases, the higher Western Australia guideline value of 30,000 Bq/kg is a more appropriate screening level.

Table Notes

NEPM - National Environment Protection Measure
BTEX - Benzene, Toluene, Ethylbenzene and Xylenes
HSL - Health Screening Level
NORM - Naturally Occurring Radioactive Material
TRH - Total Recoverable Hydrocarbons
TPH – Total Petroleum Hydrocarbons

Table C-6: Adopted Screening Criteria for RDM Solids

Analysis Parameter	Unit	Human Health Screening Criteria			Ecological Screening Criteria		
		Value	Source	RDM Depth (m)	Value	Source	RDM Depth (m)
Physico-chemical							
pH _{1:5}	pH Unit	NSL		<1.5	6 - 8	CEQG	<1.5
Cations and anions							
EC _{1:5} @ 25°C	µS/m	NSL		<1.5	465	ANZECC	<1.5
EC _{se}	dS/m	NSL		<1.5	4	ANZECC	<1.5
Chloride	mg/kg	NSL		<1.5	NSL		<1.5
Fluoride	mg/kg	3,100	RSL	<1.5	200	CEQG	<1.5
Radionuclides							
Gross alpha + Gross beta	Bq/kg	30,000	WA	All	30,000	WA	All
Total Metals							
Aluminium	mg/kg	77,000	RSL	<1.5	NSL		<1.5
Arsenic	mg/kg	300	HIL C	<1.5	40	EIL/ESL	<1.5
Barium	mg/kg	15,000	RSL	<1.5	750	CEQG	<1.5
Beryllium	mg/kg	90	HIL C	<1.5	4	CEQG	<1.5
Boron	mg/kg	20,000	HIL C	<1.5	2	CEQG	<1.5
Cadmium	mg/kg	90	HIL C	<1.5	1.4	CEQG	<1.5
Chromium	mg/kg	300	HIL C	<1.5	130*	EIL/ESL	<1.5
Cobalt	mg/kg	300	HIL C	<1.5	40	CEQG	<1.5
Copper	mg/kg	17,000	HIL C	<1.5	270*	EIL/ESL	<1.5
Lead	mg/kg	600	HIL C	<1.5	470	EIL/ESL	<1.5
Manganese	mg/kg	19,000	HIL C	<1.5	NSL		<1.5
Mercury	mg/kg	80	HIL C	<1.5	6.6	CEQG	<1.5
Molybdenum	mg/kg	390	RSL	<1.5	5	CEQG	<1.5
Nickel	mg/kg	1,200	HIL C	<1.5	45*	CEQG	<1.5
Selenium	mg/kg	700	HIL C	<1.5	1	CEQG	<1.5
Silver	mg/kg	390	RSL	<1.5	20	CEQG	<1.5
Strontium	mg/kg	47,000	RSL	<1.5	NSL		<1.5
Vanadium	mg/kg	390	RSL	<1.5	130	CEQG	<1.5
Zinc	mg/kg	30,000	HIL C	<1.5	250*	CEQG	<1.5
TRH							
C6 - C10 Fraction	mg/kg	5100	HSL	All	NSL		<1.5
C6 - C10 Fraction minus BTEX (F1)	mg/kg	370	HSL D	All	125	EIL/ESL	<1.5
>C10 - C16 Fraction	mg/kg	3,800	HSL	All	25	EIL/ESL	<1.5
>C10 - C16 Fraction minus Naphthalene (F2)	mg/kg	NSL			NSL		<1.5
>C16 - C34 Fraction	mg/kg	5,300	HSL	All	300	EIL/ESL	<1.5
>C34 - C40 Fraction	mg/kg	7,400	HSL	All	2,800	EIL/ESL	<1.5
TPH							
C6 - C9 Fraction	mg/kg						

C10 - C14 Fraction	mg/kg	No screening criteria applied for TPH - see screening criteria for TRH fractions instead					
C15 - C28 Fraction	mg/kg						
C29 - C36 Fraction	mg/kg						
BTEXN							
Benzene	mg/kg	3	HSL D	All	10	EIL/ESL	<1.5
Ethylbenzene	mg/kg	5,300	HSL	All	1.5	EIL/ESL	<1.5
Toluene	mg/kg	18,000	HSL	All	10	EIL/ESL	<1.5
Total Xylenes	mg/kg	15,000	HSL	All	10	EIL/ESL	<1.5
PAH							
Naphthalene	mg/kg	1,900**	HSL	All	10	EIL/ESL	Any depth
Acenaphthene	mg/kg	Screen Sum of PAH	HIL C	<1.5	29	ECO-SSL	<1.5
Acenaphthylene	mg/kg		HIL C	<1.5	29	ECO-SSL	<1.5
Anthracene	mg/kg		HIL C	<1.5	2.5	CEQG	<1.5
Benzo(e)pyrene	mg/kg		HIL C	<1.5	20	CEQG	<1.5
Fluoranthene	mg/kg		HIL C	<1.5	50	CEQG	<1.5
Fluorene	mg/kg		HIL C	<1.5	29	ECO-SSL	<1.5
Phenanthrene	mg/kg		HIL C	<1.5	29	ECO-SSL	<1.5
Pyrene	mg/kg		HIL C	<1.5	0.1	CEQG	<1.5
Benzo(a)anthracene	mg/kg	Screen Sum of PAH and Carcinogenic PAH	HIL C	<1.5	0.1	CEQG	<1.5
Benzo(a)pyrene	mg/kg		HIL C	<1.5	0.7	EIL/ESL	<1.5
Benzo(b+j)fluoranthene	mg/kg		HIL C	<1.5	0.1	CEQG	<1.5
Benzo(g,h,i)perylene	mg/kg		HIL C	<1.5	1.1	ECO-SSL	<1.5
Benzo(k)fluoranthene	mg/kg		HIL C	<1.5	0.1	CEQG	<1.5
Chrysene	mg/kg		HIL C	<1.5	1.1	ECO-SSL	<1.5
Dibenz(a,h)anthracene	mg/kg		HIL C	<1.5	0.1	CEQG	<1.5
Indeno(1.2.3.cd)pyrene	mg/kg		HIL C	<1.5	0.1	CEQG	<1.5
Carcinogenic PAHs (as Benzo(a)pyrene TEQ)	mg/kg	3	HIL C	<1.5	NSL		<1.5
Sum of polycyclic aromatic hydrocarbons (PAHs)	mg/kg	300	HIL C	<1.5	NSL		<1.5

Table Notes:

*EILs for chromium, copper, nickel and zinc will be updated with consideration of site-specific data in accordance with the ASC NEPM as part of the future sampling programs at Jibera South and Newcastle South

**The HSL for naphthalene relates to the volatile phase

ANZECC Australian and New Zealand Environment Conservation Council

BTEX Benzene, toluene, ethylbenzene, and xylene

CEQG Canadian Environmental Quality Guidelines

ECO-SSL Ecological soil screening level

EIL Ecological Investigation Level

ESL Ecological Screening Level

HSL C Health Screening Level (Recreational)

HIL C Health Investigation Level (Recreational)

ML Management Limit (defaults to this value)

C_{sat} Soil saturation concentration (defaults to this value)

Table C-7: Adopted Screening Criteria for RDM Leachate

Analysis Parameter	Units	Human Health Screening Criteria		Ecological Screening Criteria	
		Human health and ecological screening criteria do not apply if leaching to groundwater is an incomplete exposure pathway.			
		Value	Source	Value	Source
Cations and anions					
Chloride (soluble)	mg/L	250	ADWG (aesthetic)	NSL	
Radionuclides					
Gross alpha activity	Bq/L	0.5	ADWG (health)	NSL	
Gross beta activity	Bq/L	N/A	n/a	NSL	
Gross beta activity - ⁴⁰ K	Bq/L	0.5	ADWG (health)	NSL	
Total Metals					
Aluminium	mg/L	0.2	ADWG (aesthetic)	0.055	NEPM GIL
Arsenic	mg/L	0.01	ADWG (health)	0.013	NEPM GIL
Barium	mg/L	2	ADWG (health)	NSL	
Beryllium	mg/L	0.06	ADWG (health)	NSL	
Boron	mg/L	4	ADWG (health)	0.37	NEPM GIL
Cadmium	mg/L	0.002	ADWG (health)	0.0002	NEPM GIL
Chromium	mg/L	0.05	AWDG (health, CrVI)	0.001	NEPM GIL
Cobalt	mg/L	0.006	RSL PGW	NSL	
Copper	mg/L	2	ADWG (health)	0.0014	NEPM GIL
Lead	mg/L	0.01	ADWG (health)	0.0034	NEPM GIL
Manganese	mg/L	0.5	ADWG (health)	1.9	NEPM GIL
Mercury	mg/L	0.001	ADWG (health)	0.00006	NEPM GIL
Molybdenum	mg/L	0.05	ADWG (health)	NSL	
Nickel	mg/L	0.02	ADWG (health)	0.011	NEPM GIL
Selenium	mg/L	0.01	ADWG (health)	0.005	NEPM GIL
Silver	mg/L	0.1	ADWG (health)	0.00005	NEPM GIL
Strontium	mg/L	12	RSL PGW	NSL	
Vanadium	mg/L	0.086	RSL PGW	NSL	
Zinc	mg/L	3	ADWG (health)	0.008	NEPM GIL

Table Notes:

ADWG Australian Drinking Water Guidelines
 health Criteria based on health-based value
 aesthetic Criteria defaults to aesthetic-based value
 RSL PGW Regional Screening Levels for Protection of Groundwater
 GIL Groundwater Investigation Level
 NSL No screening level available
 Refer to text for sources of screening levels.

2.3.1. Interpreting RDM Results Against Screening Criteria

Analysis results from RDM solids samples will be compared to respective screening criteria. Note that comparison of leachate results to ADWG, NEPM GILs, RSL PGW guideline values is not applicable because there are no complete exposure pathways for groundwater. However, leachate analysis will be undertaken as a matter of course, in line with the requirements of the Code of Practice.

Where a complete or potentially complete exposure pathway exists and a relevant criterion is exceeded, further evaluation will be undertaken to determine if a long-term risk is present. This may include completion of the following:

- Development and application of site-specific criteria (in lieu of the generic screening criteria adopted for this assessment).
- If shallow groundwater is present and/or the requisite thicknesses of Cretaceous stratigraphy is not present, additional infiltration modelling to demonstrate whether seepage to groundwater is plausible.
- Increase in the burial and cover depth and reapplication of screening criteria (as per above) in accordance with the updated burial methodology.
- To the extent that the burial methodology criteria are not met and a modified burial methodology is required, separate certification of the modified burial methodology in accordance with Section C.4.1.2 of the Code of Practice will be obtained.

2.3.2. Representative RDM Sampling Program

A representative sampling program will be implemented to obtain analytical data suitable for comparison with the adopted screening criteria, and as otherwise required by the Code of Practice. Sampling and analysis will be undertaken in accordance with *Section C.4.1.2* and *Table 9 Analytes and method for drilling waste assessment* of the Code of Practice (refer to details provided in Section 9). All analytical results will be stored in Santos Ltd EQUIS (Environmental Quality Information System) database. Analytical results for relevant analysis parameters (RDM solids) will be screened against the screening criteria provided in Table C-6 and Table C-7.

The sampling and analysis program will be designed to ensure statistical representativeness of the RDM and otherwise will follow recognised industry guidelines and standards for stockpile sampling, as appropriate. An appropriate quality assurance/quality control program will also be undertaken based on the requirements outlined in Schedule B2 of the ASC NEPM (NEPC, 2013) with reference to standard AS 4482.1-2005 (Standards Australia, 2005).

It is anticipated that the main body of the RDM will be characterised through the collection of a sufficient number of samples (e.g. more than ten) distributed across the stockpile and from representative depth intervals to capture spatial variability in contaminant concentrations. Ancillary RDM materials, such as smaller quantities of RDM located in the secondary cuttings pit, will also be sampled to characterise these materials adequately. Analytical results may be compared to screening levels on a point-by-point basis for individual samples or through calculation of upper confidence limit (UCL) values of the mean, where appropriate, to provide a statistically robust basis for assessment. This approach will ensure that the dataset accurately represents the overall contaminant profile of the RDM and supports a defensible comparison with the applicable screening criteria.

2.4. Offset Well Analysis Results and Screening Summary

The proposed Jibera South and Newcastle South drilling campaigns will follow the same approach as for the drilling of appraisal wells at Mount Brown. The drilling fluid composition, drilling process, and drill fluid management practices be effectively the same or similar to those previously used for the Mount Brown exploration drilling program. In addition, although there may be minor variations in the thicknesses and depths of stratigraphic layers, the anticipated overall geological profile and lithological composition are highly comparable between each of the three locations.

Based on these similarities, the RDM composition and chemical profile of the RDM generated at Jibera South and Newcastle south is expected to have a chemical composition consistent with that measured at Mount Brown.

Representative sampling and analysis of RDM was previously undertaken at Mount Brown in December 2022 and October 2023. Given the similarity in drilling methods and geological conditions, these results are considered indicative of the RDM composition that will be generated during the upcoming drilling campaigns at Jibera South and Newcastle South, and will have been used to inform the design of the RDM methodology.

The following sections provide an overview of the Mount Brown RDM analysis results to inform the expected RDM composition for the planned drilling program. Attachment C-1 includes summary statistics and detailed radiological analysis results from the December 2022 and October 2023 RDM sampling events.

Table C-78 compares the Mount Brown RDM Solids Analysis Results with Adopted Screening Criteria. Based on these results, none of the results from the offset site exceeded the screening criteria. With the exception of TRH >C10 – C16 and >C16 – C34 fractions, the results were typically more than an order of magnitude lower than the respective screening criteria. For TRH >C10 – C16 and >C16 – C34 fractions, the mean results for the December 2022 samples, which represented the main body of the RDM, were about an order of magnitude lower than the respective screening criteria, and for the October 2023 results, representing a minor proportion of the RDM, were approximately half of the screening criteria. These results indicate that the RDM generated from the Jibera South and Newcastle South wells is unlikely to contain contaminant concentrations exceeding respective screening criteria.

Table C-8: Comparison of Mount Brown RDM Solids Analysis Results with Adopted Screening Criteria

Parameter	Unit	Typical LOR	Detection Frequency	Screening Criteria	Screening Criteria Source	December 2022 Samples					October 2023 Samples		
						Min	Max	Mean	Median	95% Student T UCL	Max	Min	Mean
Radionuclides													
Gross alpha	Bq/kg DW	500	12 / 14	30,000	WA	610	4,090	1,861	1,525	2,630	2,650	1,090	1,870
Gross Beta	Bq/kg DW	500	12 / 14	30,000	WA	530	1,800	1,138	1,125	1,373	1,470	1,440	1,455
TRH													
C6 - C10 Fraction	mg/kg	10	4 / 14	700	HSL (ML)	10	16	11.38	10	13.09	23	22	22.5
C6 - C10 Fraction minus BTEX (F1)	mg/kg	10	4 / 14	370	HSL D	10	16	11.38	10	13.09	23	<10	22.5
>C10 - C16 Fraction	mg/kg	50	6 / 14	1,000	HSL (ML)	50	150	73.75	55	97.75	600	470	540
>C10 - C16 Fraction minus Naphthalene (F2)	mg/kg	50	7 / 14	1,000	HSL (ML)	50	150	73.75	55	97.75	600	470	540
>C16 - C34 Fraction	mg/kg	100	7 / 14	2,500	HSL (ML)	100	350	172.5	130	234.8	1,200	510	870
>C34 - C40 Fraction	mg/kg	100	1 / 14	10,000	HSL (ML)	Not Detected					110	110	110
BTEXN													
Benzene	mg/kg	0.2	0 / 14	3	HSL D	Not Detected					Not Detected		
Ethylbenzene	mg/kg	0.5	0 / 14	64	HSL (ML)	Not Detected					Not Detected		
Toluene	mg/kg	0.5	0 / 14	560	HSL (ML)	Not Detected					Not Detected		
Total Xylenes	mg/kg	0.5	0 / 14	300	HSL (ML)	Not Detected					Not Detected		
Naphthalene	mg/kg	0.01	0 / 14	9	HSL (C _{sat})	Not Detected					Not Detected		

2.4.1. BTEXN and PAH

Benzene, toluene, ethylbenzene, xylenes and naphthalene (BTEXN) constituents were not detected in any of the RDM solids samples. All results were below the respective laboratory LOR and respective human health and ecological criteria. Polycyclic aromatic hydrocarbons (PAH) constituents were not detected in any of the samples with the exception of phenanthrene, which was detected in one of the RDM solids samples (and the corresponding duplicate) at levels below relevant human health and ecological criteria.

These results indicate that the BTEXN and PAH constituents in the RDM are not likely to be present in the RDM at concentrations that would pose a plausible risk to human or ecological receptors. In addition, the Code of Practice: Onshore Petroleum Activities in the Northern Territory, B.5 requires specific levels for drilling materials, which further reduces the unlikelyhood of being present.

All analysis results were below the adopted screening criteria for respective BTEXN constituents.

2.4.2. TRH/ TPH

Total petroleum hydrocarbon (TPH) and total recoverable hydrocarbons (TRH) fractions were detected at low levels in six of the ten RDM samples that were collected in December 2022 and in three of the four samples that were collected in October 2023.

All fractions of TRH were detected at varying frequencies, ranging from 1 to 7 of the 14 RDM samples that were collected from the cuttings pit. All analysis results were below the adopted screening criteria for respective TRH constituents.

In the context of the site and the proposed burial methodology, placement of the RDM at > 1.5 metres depth would effectively mitigate potential risks to ecological receptors.

2.4.3. EC (Salinity) and Chloride

EC_{1:5} and calculated EC_{se} values for the RDM ranged from 7,250 to 56,853 $\mu\text{S}/\text{cm}$ and 62 to 360 dS/m, respectively. Similarly, chloride, a major anion in the drilling fluids, ranged from 3,450 to 160,000 mg/kg. These values reflect the high residual salinity of the RDM from salts in the drilling fluids, and it is anticipated that similar levels will be present in the RDM generated from Jibera South and Newcastle South. The major cations and anions in the RDM have a low toxicity, and would not present a risk to human health. However, the elevated salinity of the RDM would make it unsuitable as a growth medium for plants, and would impair plant growth if placed within the primary root zone of pasture grass species (i.e., typically within the upper 0.6 m of the land surface). Placement of this material at >1.5 metres depth (i.e., below the primary root zone of pasture grass species) will mitigate potential effects on root zone salinity and plant growth.

The chloride and other salts are readily leachable, and could theoretically present aesthetic impacts to shallow groundwater if a complete contaminant transport pathway to groundwater was present. Chloride leachate results exceeded the ADWG for aesthetic impacts. However, as discussed in the preceding sections, the shallow lithology has a low permeability and shallow groundwater is not likely present, and therefore the leachability of salts in the RDM is not expected to present a risk.

2.4.4. pH

The pH of the RDM material ranged from 7.4 to 10.6, with mean values of approximately 9, making the material moderately alkaline. Whilst these pH values would not present a risk to human health or preclude plant growth, the overall pH is slightly higher than the optimum range of approximately 6 to 9 (based on pH_{1:5}) for plant growth (NSW Agriculture, 2000). Placement of the material below the root zone depth would mitigate impediments to plant growth associated with the pH of the RDM. Alternately, the RDM material could be ameliorated to reduce pH, although this is not considered necessary for the proposed management measures.

2.4.5. Fluoride

The fluoride concentrations in the RDM ranged from 40 to 530 mg/kg, with a mean concentration of approximately 300 mg/kg. It should be noted, the RDM results represent total (as opposed to soluble) fluoride and that fluoride is not a constituent used in drilling fluids.

Placement of the RDM at >1.5 metres depth would mitigate potential risks to cattle and ecological receptors, including indirect including indirect exposures arising from fluoride uptake by plants and subsequent ingestion by cattle (although minimal potential ingestion would occur given the very large scale of the potential grazing area relative to the size of burial area).

2.4.6. Total Metals

Of the metals that were analysed, the concentrations in respective samples were below NEPM HIL D human health screening levels, and therefore are unlikely to pose a risk to workers even if the RDM material were buried at an accessible depth. Seven metals species, including barium, boron, cadmium, copper, molybdenum, selenium and strontium exceeded ecological screening levels (NEPM EILs/ESLs and/or CEQG) in one or more samples. However, the exposure pathway is considered incomplete for ecological receptors and therefore these criteria do not apply if the RDM is placed at >1.5 metres depth.

The majority of metals results from the leachate samples were below the respective ADWG and/or USEPA RSL screening levels. The maximum detected leachate concentrations of aluminium, barium, cadmium, chromium, cobalt, lead, molybdenum and nickel concentrations exceeded ADWG and/or USEPA RSL screening levels. However, mean concentrations of these constituents were below these screening levels, indicating that leachate from the RDM would be unlikely to pose a risk to groundwater even if groundwater exposure pathways were potentially complete.

Notwithstanding, as discussed in the preceding sections, groundwater exposure pathways are not considered complete, and therefore groundwater screening criteria are not applicable.

2.4.7. Radionuclides

The maximums and 95% UCL of the mean for gross alpha and gross beta exceeded the ARPANSA threshold for NORM of 1000 Bq/kg, with maximum gross alpha ranging from 2650 to 4090 Bq/kg and maximum gross beta ranging from 1470 to 1800 Bq/kg. However, these activity concentrations were generally an order of magnitude less than the Western Australia threshold of 30,000 Bq/kg. Similar activity concentrations are expected to occur in the RDM from Jibera South and Newcastle South, and are not likely to pose a risk to human health or ecological receptors, particularly if placed under a cover material of native soils, which would provide a high level of shielding. Based on a burial depth of 1.5 metres, the estimated maximum dose after 1,000 years was 0.003 mSv/year, which is 0.3 per cent (or more than 300x lower than the dose limit of 1 mSv/year. Based on these results, it is not anticipated that the RDM from Jibera South or Newcastle South will pose a potential human health or ecological risk with respect to radionuclide activity.

The leachate results for gross alpha and beta activity showed no detectable activity in the leachate above the respective LOR for individual results. The LOR for gross alpha and gross beta activity (corrected for ⁴⁰K beta activity) ranged from 0.05 to 0.11 Bq/L and 0.1 to 0.22 Bq/L. All of these values are lower than the Australian Drinking Water Guidelines (ADWG) of 0.5 Bq/L for gross alpha and gross beta activity concentration. Therefore, leaching of radionuclides is unlikely to pose a potential environmental risk even if the groundwater pathway were to be considered complete.

Attachment C-1

Residual drilling material solids analysis results – Mount Brown

Parameter	Unit	Typi cal LOR	Detection Frequency	December 2022 Samples						October 2023 Samples		
				Min	Max	SD	Mean	Median	95% Student UCL	Max	Min	Mean
Physico-chemical												
EC @ 25°C	µS/m	0.1	14 / 14	7,250	21,600	5,250	16,030	18,000	19,550	56,853	27,522	41,903
ECse (Clay Loams and Light/Sandy Clays CF 8.6)	dS/m		14 / 14	62	186	45	138	155	168	489	237	360
pH 1:5 Lab	pH Unit	0.1	14 / 14	8.3	10.6	0.8	9.1	9.0	9.6	8.6	7.4	7.9
Chloride	mg/kg	10	14 / 14	3,450	49,700	15,444	32,044	36,550	42,388	2E+05	98,500	1E+05
Fluoride	mg/kg	40	13 / 14	40	530	192	304	315	433	380	330	358
Moisture content	%	0.1	14 / 14	12.6	29.1	6.431	21.14	20.45	25.45	45.7	21.3	31.45
Radionucleotides												
Gross alpha	Bq/kg DW	500	12 / 14	610	4,090	1,148	1,861	1,525	2,630	2,650	1,090	1,870
Gross Beta	Bq/kg DW	500	12 / 14	530	1,800	351.2	1,138	1,125	1,373	1,470	1,440	1,455
Nutrients												
Total Nitrogen as N	mg/kg	20	14 / 14	500	1,770	431	1,008	1,035	1,296	4,390	2,100	3,388
Total Phosphorus as P	mg/kg	2	14 / 14	79	1,180	408	538	479	811	460	315	376
Total Organic Carbon	%	0.02	14 / 14	0.13	5.43	1.9	2.7	2.7	4.0	4.9	3.3	4.2
Total Carbon (soil)	%	0.02	14 / 14	0.53	6.61	2.2	3.7	4.1	5.2	5.1	3.8	4.7
Total Inorganic Carbon	%	0.02	14 / 14	0.4	2.34	0.7	1.1	0.9	1.5	0.6	0.1	0.5

Parameter	Unit	Typical LOR	Detection Frequency	December 2022 Samples						October 2023 Samples		
				Min	Max	SD	Mean	Median	95% Student UCL	Max	Min	Mean
ANC as CaCO ₃	% CaCO ₃	0.1	10 / 14	2.4	53	17	12	6	N/A			
ANC as H ₂ SO ₄	kg H ₂ SO ₄ equiv.	0.5	10 / 14	23	524	168	114	58	N/A			
Total Metals												
Aluminium	mg/kg	50	14 / 14	940	7,490	2335	3981	3520	5545	5530	3590	4740
Arsenic	mg/kg	0.1	14 / 14	0.6	17.4	6.2	9.4	9.6	13.5	7.2	5.8	6.5
Barium	mg/kg	0.1	14 / 14	757	3910	1001	1960	1875	2630	2670	916	1889
Beryllium	mg/kg	0.1	13 / 14	0.1	0.6	0.2	0.4	0.4	0.5	0.6	0.2	0.5
Boron	mg/kg	5	11 / 14	5	22	6	12	10	16	30	17	22
Cadmium	mg/kg	0.1	11 / 14	0.1	2.6	1.0	1.1	0.9	1.8	0.6	0.3	0.5
Chromium	mg/kg	0.1	14 / 14	2.7	35.6	11	23	24	30	53	35	45
Cobalt	mg/kg	0.1	14 / 14	1.5	7.2	2	4	4	6	6	4	5
Copper	mg/kg	0.1	14 / 14	3.7	124	45	51	43	81	53	40	45
Lead	mg/kg	0.1	14 / 14	1	13.7	5	8	8	12	10	7	9
Manganese	mg/kg	0.1	14 / 14	21.2	209	63	113	125	155	62	41	52
Molybdenum	mg/kg	0.1	14 / 14	0.4	18.3	7	9	8	13	35	14	24
Nickel	mg/kg	0.1	14 / 14	3.1	46.1	16	24	25	35	38	24	32
Selenium	mg/kg	1	3 / 14	1	2	0.4	1.1	1.0	1.4	ND		
Silver	mg/kg	0.1	10 / 14	0.1	0.4	0.1	0.2	0.2	0.3	0.2	0.1	0.2
Strontium	mg/kg	0.1	14 / 14	16	99.1	26	47	39	64	23	12	18
Vanadium	mg/kg	1	14 / 14	6	46	14	29	31	39	67	28	55
Zinc	mg/kg	0.5	14 / 14	5.2	168	66	82	73	126	86	63	76

Parameter	Unit	Typical LOR	Detection Frequency	December 2022 Samples						October 2023 Samples		
				Min	Max	SD	Mean	Median	95% Student UCL	Max	Min	Mean
Mercury	mg/kg	0.01	12 / 14	0.01	0.12	0.0	0.1	0.1	0.1	0.1	0.0	0.0
TRH												
C6 - C10 Fraction	mg/kg	10	4 / 14	10	16	2.56	11.38	10	13.09	23	22	22.5
C6 - C10 Fraction minus BTEX (F1)	mg/kg	10	4 / 14	10	16	2.56	11.38	10	13.09	23	<10	22.5
>C10 - C16 Fraction	mg/kg	50	6 / 14	50	150	35.38	73.75	55	97.75	600	470	540
>C10 - C16 Fraction minus Naphthalene (F2)	mg/kg	50	7 / 14	50	150	35.38	73.75	55	97.75	600	470	540
>C16 - C34 Fraction	mg/kg	100	7 / 14	100	350	93.01	172.5	130	234.8	1200	510	870
>C34 - C40 Fraction	mg/kg	100	1 / 14	ND						110	110	110
TPH												
C6 - C9 Fraction	mg/kg	10	1 / 14	10	10	10	10	10	10	NA	NA	NA
C10 - C14 Fraction	mg/kg	50	1 / 14	50	90	14.14	55	50	64.47	NA	NA	NA
C15 - C28 Fraction	mg/kg	100	5 / 14	100	330	91.14	187.5	170	248.6	NA	NA	NA
C29 - C36 Fraction	mg/kg	100	0 / 14	ND						NA	NA	NA
BTEXN												
Benzene	mg/kg	0.2	0 / 14	ND						ND		
Ethylbenzene	mg/kg	0.5	0 / 14	ND						ND		
Toluene	mg/kg	0.5	0 / 14	ND						ND		
Total Xylenes	mg/kg	0.5	0 / 14	ND						ND		
Sum of BTEX	mg/kg	0.2	0 / 10	ND						ND		
PAH												
Acenaphthene	mg/kg	0.01	0 / 14	ND						ND		

Parameter	Unit	Typical LOR	Detection Frequency	December 2022 Samples						October 2023 Samples		
				Min	Max	SD	Mean	Median	95% Student UCL	Max	Min	Mean
Acenaphthylene	mg/kg	0.01	0 / 14	ND						ND		
Anthracene	mg/kg	0.01	0 / 14	ND						ND		
Benzo(a)anthracene	mg/kg	0.01	0 / 14	ND						ND		
Benzo(a)pyrene	mg/kg	0.01	0 / 14	ND						ND		
Benzo(b+j)fluoranthene	mg/kg	0.01	0 / 14	ND						ND		
Benzo(e)pyrene	mg/kg	0.01	0 / 14	ND						ND		
Benzo(g,h,i)perylene	mg/kg	0.01	0 / 14	ND						ND		
Benzo(k)fluoranthene	mg/kg	0.01	0 / 14	ND						ND		
Chrysene	mg/kg	0.01	0 / 14	ND						ND		
Dibenz(a,h)anthracene	mg/kg	0.01	0 / 14	ND						ND		
Fluoranthene	mg/kg	0.01	0 / 14	ND						ND		
Fluorene	mg/kg	0.01	0 / 14	ND						ND		
Indeno(1,2,3-cd)pyrene	mg/kg	0.01	0 / 14	ND						ND		
Naphthalene	mg/kg	0.01	0 / 14	ND						ND		
Phenanthrene	mg/kg	0.01	1 / 14	0.04	0.04	0.04	0.04	0.04	0.04	ND		
Pyrene	mg/kg	0.01	0 / 14	ND						ND		
Sum of polycyclic aromatic hydrocarbons (PAHs)	mg/kg	0.01	3 / 14	0.01	0.11	NC	NC	NC	NC	0.01	0.01	0.01

Residual drilling material solids analysis results – Mount Brown

Chemicals	Units	LOR	December 2022 Summary Statistics					October 2023 Summary Statistics				
			Min	Max	Mean	Median	Detection Frequency	Min	Max	Mean	Median	Detection Frequency
Cations and anions												
Chloride	mg/L	1	850	1960	1500	1595	4 / 4	3320	6540	4720	4510	4 / 4
Final pH (inorganic/non-volatile)	pH Unit	0.1	5.2	5.2	5.2	5.2	4 / e 4	ND	ND	ND	ND	0 / 4
Final pH (DI water)	pH Unit	0.1	7.1	8.6	8.025	8.2	4 / 4	6.7	7.3	7.1	7.1	4 / 4
Radionuclides												
Gross alpha	Bq/L	0.05 - 0.11	ND	ND	ND	ND	0 / 4	ND	ND	ND	ND	0 / 4
Gross beta activity - 40K	Bq/L	0.1 - 0.22	ND	ND	ND	ND	0 / 4	ND	ND	ND	ND	0 / 4
Total Metals												
Aluminium	mg/L	0.01	0.04	0.76	0.4575	0.515	4 / 4	72.8	124	99.2	100	4 / 4
Arsenic	mg/L	0.001	0.004	0.008	0.0063	0.0065	4 / 4	0.061	0.098	0.0803	0.081	4 / 4
Barium	mg/L	0.001	0.495	4.94	2.37	2.025	4 / 4	261	317	286.25	283.5	4 / 4
Beryllium	mg/L	0.001	ND	ND	ND	ND	0 / 4	0.0120	0.012	0.012	0.012	1 / 4
Boron	mg/L	0.05	0.06	0.84	0.395	0.34	4 / 4	ND	ND	ND	ND	0 / 4
Cadmium	mg/L	0.0001	0.0002	0.0002	0.0002	0.0002	1 / 4	0.0105	0.013	0.0118	0.0118	4 / 4
Chromium	mg/L	0.001	0.002	0.008	0.005	0.005	2 / 4	0.59	1.08	0.798	0.761	4 / 4
Cobalt	mg/L	0.001	ND	ND	ND	ND	0 / 4	0.059	0.085	0.0723	0.0725	4 / 4
Copper	mg/L	0.001	0.002	0.007	0.004	0.003	3 / 4	0.712	1.06	0.8675	0.849	4 / 4
Lead	mg/L	0.001	ND	ND	ND	ND	0 / 4	0.111	0.187	0.1595	0.17	4 / 4
Manganese	mg/L	0.001	0.002	0.018	0.0088	0.0075	4 / 4	0.719	1.05	0.909	0.9335	4 / 4
Mercury	mg/L	0.0001	ND	ND	ND	ND	0 / 4	ND	ND	ND	ND	0 / 4
Molybdenum	mg/L	0.001	0.059	0.108	0.0773	0.071	4 / 4	0.401	0.9	0.6795	0.7085	4 / 4
Nickel	mg/L	0.001	0.011	0.03	0.019	0.0175	4 / 4	0.47	0.856	0.633	0.603	4 / 4

Chemicals	Units	LOR	December 2022 Summary Statistics					October 2023 Summary Statistics				
			Min	Max	Mean	Median	Detection Frequency	Min	Max	Mean	Median	Detection Frequency
Selenium	mg/L	0.01	ND	ND	ND	ND	0 / 4	ND	ND	ND	ND	0 / 4
Silver	mg/L	0.001	ND	ND	ND	ND	0 / 4	ND	ND	ND	ND	0 / 4
Strontium	mg/L	0.001	0.142	0.313	0.2318	0.236	4 / 4	0.566	0.816	0.7143	0.7375	4 / 4
Vanadium	mg/L	0.01	0.01	0.01	0.01	0.01	2 / 4	0.6	1.29	0.9875	1.03	4 / 4
Zinc	mg/L	0.005	0.008	0.727	0.2543	0.141	4 / 4	1.29	1.98	1.6425	1.65	4 / 4
BTEXN												
Benzene	µg/L	1	ND	ND	ND	ND	0 / 4	ND	ND	ND	ND	0 / 0
Ethylbenzene	µg/L	2	ND	ND	ND	ND	0 / 4	ND	ND	ND	ND	0 / 0
meta- & para-Xylene	µg/L	2	ND	ND	ND	ND	0 / 4	ND	ND	ND	ND	0 / 0
Naphthalene	µg/L	5	ND	ND	ND	ND	0 / 4	ND	ND	ND	ND	0 / 0
ortho-Xylene	µg/L	2	ND	ND	ND	ND	0 / 4	ND	ND	ND	ND	0 / 0
Sum of BTEX	µg/L	1	ND	ND	ND	ND	0 / 4	ND	ND	ND	ND	0 / 0
Toluene	µg/L	2	ND	ND	ND	ND	0 / 4	ND	ND	ND	ND	0 / 0
Total Xylenes	µg/L	2	ND	ND	ND	ND	0 / 4	ND	ND	ND	ND	0 / 0

Residual drilling material solids analysis results (radiological) - Tanumbirini

Sample Name			TANINV18	TANINV19
Sampe Name (Original)			TANINV18_SDCOMP_22 212120000Composite of #01 - 06	TANINV19_SDCOMP _22212120000Compo site of #07 - 11
Lab Sample ID			EB2316297-012	EB2316297-013
Sample Date			12/12/2022	12/12/2022
			Composite of #01-06	Composite of #07-11
Analyte	LOR	Unit		
Actinium 227	1	Bq/kg DW	<10.0	<1.8
Cesium 134	1	Bq/kg DW	<1.0	<1.0
Cesium 137	1	Bq/kg DW	<1.0	<1.0
Potassium 40	10	Bq/kg DW	454	830
Protactinium 231	5	Bq/kg DW	<8.9	<5.0
Lead 210	50	Bq/kg DW	73	<50
Polonium 210	50	Bq/kg DW	172	137
Radium 223	1.0	Bq/kg DW	6.4	----
Radium 223	1	Bq/kg DW	----	<2.2
Radium 226	1.0	Bq/kg DW	182	48.9
Radium 228	1.0	Bq/kg DW	189	37.1
Thorium 227	1	Bq/kg DW	<10.0	<1.8
Thorium 228	1.0	Bq/kg DW	181	32.7
Thorium 230	50	Bq/kg DW	118	<50
Thorium 232	0.1	Bq/kg DW	140	32.7
Thorium 234	10.0	Bq/kg DW	167	43.0
Uranium 234	1	Bq/kg DW	127	48
Uranium 235	0.1	Bq/kg DW	6.5	2.2
Uranium 235	1.0	Bq/kg DW	6.5	2.2
Uranium 238	10.0	Bq/kg DW	137	47.4

Appendix D – Drilling Waste Assessment Analytes

Analytes

Analyte	Method Code	LOR	Units
Ag	iMET2SAICP	0.5	mg/kg
Al	iMET2SAICP	10	mg/kg
As	iMET2SAICP	1	mg/kg
B	iMET2SAICP	5	mg/kg
Ba	iMET2SAICP	0.1	mg/kg
Be	iMET2SAICP	0.05	mg/kg
C	(combs)	0.05	%
CO3	(combs)	0.25	%
Cd	iMET2SAICP	0.05	mg/kg
Cl	iCO1SEDA	5	mg/kg
Co	iMET2SAICP	0.1	mg/kg
Cr	iMET2SAICP	0.05	mg/kg
Cu	iMET2SAICP	0.1	mg/kg
EC_25C	iEC1SASE	0.2	ms/m
F	eF1ST	50	mg/kg
H2O_105C	iMOIS1SAGR	0.1	%
Hg	iMET2SAMS	0.02	mg/kg
Mn	iMET2SAICP	0.2	mg/kg
Mo	iMET2SAICP	0.5	mg/kg
N	(total)	0.005	%
Ni	iMET2SAICP	1	mg/kg
P	(totals)	10	mg/kg
Pb	iMET2SAICP	0.5	mg/kg
Se	iMET2SAICP	2	mg/kg
Sr	iMET2SAICP	0.2	mg/kg
TIC	(combs)	0.05	%
TOC	(combs)	0.05	%
V	iMET2SAICP	0.2	mg/kg
Zn	iMET2SAICP	5	mg/kg
pH	iPH1SASE	0.1	pH units
Benzene	eBTEXSoil	0.5	mg/kg
Toluene	eBTEXSoil	0.5	mg/kg
Ethylbenzene	eBTEXSoil	0.5	mg/kg
Xylene	eBTEXSoil	1	mg/kg

Analyte	Method Code	LOR	Units
Total BTEX	eBTEXSoil	2.5	mg/kg
C6-C9	eTPHSoils	25	mg/kg
TPH C10-C14	eTPHSoils	50	mg/kg
TPH C15-C28	eTPHSoils	100	mg/kg
TPH C29-C36	eTPHSoils	100	mg/kg
Total TPHs	eTPHSoils	275	mg/kg
Acenaphthene	ePAH1SOIL	1	mg/kg
Acenaphthylene	ePAH1SOIL	1	mg/kg
Anthracene	ePAH1SOIL	1	mg/kg
Benz(a)anthracene	ePAH1SOIL	1	mg/kg
Benzo(a)pyrene	ePAH1SOIL	1	mg/kg
Benzo(b+k)fluoranthene	ePAH1SOIL	1	mg/kg
Benzo(g,h,i)perylene	ePAH1SOIL	1	mg/kg
Chrysene	ePAH1SOIL	1	mg/kg
Dibenzo(a,h)anthracene	ePAH1SOIL	1	mg/kg
Fluoranthene	ePAH1SOIL	1	mg/kg
Fluorene	ePAH1SOIL	1	mg/kg
Indeno(1,2,3-cd)pyrene	ePAH1SOIL	1	mg/kg
Naphthalene	ePAH1SOIL	1	mg/kg
Phenanthrene	ePAH1SOIL	1	mg/kg
Pyrene	ePAH1SOIL	1	mg/kg
Total PAHs	ePAH1SOIL	16	mg/kg
Ag	iMET1WCMS	0.001	mg/L
Al	iMET1WCICP	0.05	mg/L
As	iMET1WCMS	0.001	mg/L
B	iMET1WCICP	0.05	mg/L
Ba	iMET1WCICP	0.002	mg/L
Be	iMET1WCICP	0.001	mg/L
Cd	iMET1WCMS	0.0001	mg/L
Cl	iCO1WCDA	1	mg/L
Co	iMET1WCICP	0.005	mg/L
Cr	iMET1WCICP	0.001	mg/L
Cu	iMET1WCMS	0.001	mg/L

Analyte	Method Code	LOR	Units
Hg	iHG1WCVG	0.0001	mg/L
Hg	iMET1WCMS	0.0001	mg/L
Mn	iMET1WCICP	0.001	mg/L
Mo	iMET1WCMS	0.001	mg/L
Ni	iMET1WCMS	0.001	mg/L
Pb	iMET1WCMS	0.001	mg/L
Se	iMET1WCMS	0.001	mg/L
Sr	iMET1WCICP	0.001	mg/L
V	iMET1WCICP	0.005	mg/L
Zn	iMET1WCICP	0.005	mg/L
pH_ASLP	iASLP	0.1	pH unit
Gross	Alpha	0.05	Bq/L
Gross	Beta	0.1	Bq/L

Appendix E – Screening Criteria for RDM Solids and Leachate

Adopted Screening Criteria for RDM Solids

Analysis Parameter	Unit	Human Health Screening Criteria			Ecological Screening Criteria		
		Value	Source	RDM Depth (m)	Value	Source	RDM Depth (m)
Physico-chemical							
pH _{1:5}	pH Unit	NSL		<1.5	6 - 8	CEQG	<1.5
Cations and anions							
EC _{1:5} @ 25°C	µS/m	NSL		<1.5	465	ANZECC	<1.5
EC _{se}	dS/m	NSL		<1.5	4	ANZECC	<1.5
Chloride	mg/kg	NSL		<1.5	NSL		<1.5
Fluoride	mg/kg	3100	RSL	<1.5	200	CEQG	<1.5
Radionuclides							
Gross alpha + Gross beta	Bq/kg	30000	WA	All	30000	WA	All
Total Metals							
Aluminium	mg/kg	77000	RSL	<1.5	NSL		<1.5
Arsenic	mg/kg	300	HIL C	<1.5	40	EIL/ESL	<1.5
Barium	mg/kg	15000	RSL	<1.5	750	CEQG	<1.5
Beryllium	mg/kg	90	HIL C	<1.5	4	CEQG	<1.5
Boron	mg/kg	20000	HIL C	<1.5	2	CEQG	<1.5
Cadmium	mg/kg	90	HIL C	<1.5	1.4	CEQG	<1.5
Chromium	mg/kg	300	HIL C	<1.5	130*	EIL/ESL	<1.5
Cobalt	mg/kg	300	HIL C	<1.5	40	CEQG	<1.5
Copper	mg/kg	17000	HIL C	<1.5	270*	EIL/ESL	<1.5
Lead	mg/kg	600	HIL C	<1.5	470	EIL/ESL	<1.5
Manganese	mg/kg	19000	HIL C	<1.5	NSL		<1.5
Mercury	mg/kg	80	HIL C	<1.5	6.6	CEQG	<1.5
Molybdenum	mg/kg	390	RSL	<1.5	5	CEQG	<1.5
Nickel	mg/kg	1200	HIL C	<1.5	45*	CEQG	<1.5
Selenium	mg/kg	700	HIL C	<1.5	1	CEQG	<1.5
Silver	mg/kg	390	RSL	<1.5	20	CEQG	<1.5
Strontium	mg/kg	47000	RSL	<1.5	NSL		<1.5
Vanadium	mg/kg	390	RSL	<1.5	130	CEQG	<1.5
Zinc	mg/kg	30000	HIL C	<1.5	250*	CEQG	<1.5
TRH							
C6 - C10 Fraction	mg/kg	5100	HSL	All	NSL		<1.5

C6 - C10 Fraction minus BTEX (F1)	mg/kg	370	HSL D	All	125	EIL/ESL	<1.5
>C10 - C16 Fraction	mg/kg	3800	HSL	All	25	EIL/ESL	<1.5
>C10 - C16 Fraction minus Naphthalene (F2)	mg/kg	NSL			NSL		<1.5
>C16 - C34 Fraction	mg/kg	5300	HSL	All	300	EIL/ESL	<1.5
>C34 - C40 Fraction	mg/kg	7400	HSL	All	2800	EIL/ESL	<1.5
TPH							
C6 - C9 Fraction	mg/kg	No screening criteria applied for TPH - see screening criteria for TRH fractions instead					
C10 - C14 Fraction	mg/kg						
C15 - C28 Fraction	mg/kg						
C29 - C36 Fraction	mg/kg						
BTEXN							
Benzene	mg/kg	3	HSL D	All	10	EIL/ESL	<1.5
Ethylbenzene	mg/kg	5300	HSL	All	1.5	EIL/ESL	<1.5
Toluene	mg/kg	18000	HSL	All	10	EIL/ESL	<1.5
Total Xylenes	mg/kg	15000	HSL	All	10	EIL/ESL	<1.5
PAH							
Naphthalene	mg/kg	1900**	HSL	All	10	EIL/ESL	Any depth
Acenaphthene	mg/kg	Screen Sum of PAH	HIL C	<1.5	29	ECO-SSL	<1.5
Acenaphthylene	mg/kg		HIL C	<1.5	29	ECO-SSL	<1.5
Anthracene	mg/kg		HIL C	<1.5	2.5	CEQG	<1.5
Benzo(e)pyrene	mg/kg		HIL C	<1.5	20	CEQG	<1.5
Fluoranthene	mg/kg		HIL C	<1.5	50	CEQG	<1.5
Fluorene	mg/kg		HIL C	<1.5	29	ECO-SSL	<1.5
Phenanthrene	mg/kg		HIL C	<1.5	29	ECO-SSL	<1.5
Pyrene	mg/kg	Screen Sum of PAH and Carcinogenic PAH	HIL C	<1.5	0.1	CEQG	<1.5
Benzo(a)anthracene	mg/kg		HIL C	<1.5	0.1	CEQG	<1.5
Benzo(a)pyrene	mg/kg		HIL C	<1.5	0.7	EIL/ESL	<1.5
Benzo(b+j)fluoranthene	mg/kg		HIL C	<1.5	0.1	CEQG	<1.5
Benzo(g,h,i)perylene	mg/kg		HIL C	<1.5	1.1	ECO-SSL	<1.5
Benzo(k)fluoranthene	mg/kg		HIL C	<1.5	0.1	CEQG	<1.5
Chrysene	mg/kg		HIL C	<1.5	1.1	ECO-SSL	<1.5

Dibenz(a,h)anthracene	mg/kg		HIL C	<1.5	0.1	CEQG	<1.5
Indeno(1.2.3.cd)pyrene	mg/kg		HIL C	<1.5	0.1	CEQG	<1.5
Carcinogenic PAHs (as Benzo(a)pyrene TEQ)	mg/kg	3	HIL C	<1.5	NSL		<1.5
Sum of polycyclic aromatic hydrocarbons (PAHs)	mg/kg	300	HIL C	<1.5	NSL		<1.5

Table Notes:

*EILs for chromium, copper, nickel and zinc will be updated with consideration of site-specific data in accordance with the ASC NEPM as part of the future sampling programs at Jibera South and Newcastle South

**The HSL for naphthalene relates to the volatile phase

ANZECC Australian and New Zealand Environment Conservation Council

BTEX benzene, toluene, ethylbenzene, and xylene

CEQG Canadian Environmental Quality Guidelines

ECO-SSL ecological soil screening level

EIL Ecological Investigation Level

ESL Ecological Screening Level

HSL C Health Screening Level (Recreational)

HIL C Health Investigation Level (Recreational)

ML Management Limit (defaults to this value)

NSL No Screening Level

C_{sat} Soil saturation concentration (defaults to this value)

Table E-1 Adopted Screening Criteria for RDM Leachate

Analysis Parameter	Units	Human Health Screening Criteria		Ecological Screening Criteria	
		Human health and ecological screening criteria do not apply if leaching to groundwater is an incomplete exposure pathway			
		Value	Source	Value	Source
Cations and anions					
Chloride (soluble)	mg/L	250	ADWG (aesthetic)	NSL	
Radionuclides					
Gross alpha activity	Bq/L	0.5	ADWG (health)	NSL	
Gross beta activity	Bq/L	N/A	n/a	NSL	
Gross beta activity - ⁴⁰ K	Bq/L	0.5	ADWG (health)	NSL	
Total Metals					
Aluminium	mg/L	0.2	ADWG (aesthetic)	0.055	NEPM GIL
Arsenic	mg/L	0.01	ADWG (health)	0.013	NEPM GIL
Barium	mg/L	2	ADWG (health)	NSL	
Beryllium	mg/L	0.06	ADWG (health)	NSL	
Boron	mg/L	4	ADWG (health)	0.37	NEPM GIL
Cadmium	mg/L	0.002	ADWG (health)	0.0002	NEPM GIL
Chromium	mg/L	0.05	AWDG (health, CrVI)	0.001	NEPM GIL
Cobalt	mg/L	0.006	RSL PGW	NSL	
Copper	mg/L	2	ADWG (health)	0.0014	NEPM GIL
Lead	mg/L	0.01	ADWG (health)	0.0034	NEPM GIL
Manganese	mg/L	0.5	ADWG (health)	1.9	NEPM GIL
Mercury	mg/L	0.001	ADWG (health)	0.00006	NEPM GIL
Molybdenum	mg/L	0.05	ADWG (health)	NSL	
Nickel	mg/L	0.02	ADWG (health)	0.011	NEPM GIL
Selenium	mg/L	0.01	ADWG (health)	0.005	NEPM GIL
Silver	mg/L	0.1	ADWG (health)	0.00005	NEPM GIL
Strontium	mg/L	12	RSL PGW	NSL	
Vanadium	mg/L	0.086	RSL PGW	NSL	
Zinc	mg/L	3	ADWG (health)	0.008	NEPM GIL

Table Notes:

ADWG Australian Drinking Water Guidelines
 health Criteria based on health-based value
 aesthetic Criteria defaults to aesthetic-based value
 RSL PGW Regional Screening Levels for Protection of Groundwater
 GIL Groundwater Investigation Level
 NSL No screening level available
 Refer to text for sources of screening levels

Appendix F – Residual Drilling Material Risk Assessment

Risk Event	Potential Impact	Relevant Environmental Factor	Risk Source	Initial Risk Ranking*			RDM Burial Method Controls and Management Measures	Residual Risk Ranking*			Effective Controls	Uncertainty Ranking
				C	L	R		C	L	R		
Direct contact risk for human receptors	Landholder or worker comes into contact with RDM causing illness or injury	Terrestrial Environmental Quality	RDM contaminants concentrations	IV	D	H	Future radiation assessment(s) of RDM should consider the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) codes and guides published as part of the 'Radiation Protection Series' to inform the appropriate classification, management and disposal of radioactive substances, including NORM. Historical EP 161 results indicate that concentration of constituents in RDM are anticipated to be typically below NEPM HSL's and HIL's, but may contain low levels of radiological material above NORM. Evidence suggests 0.7 m of soil cover provides significant shielding of emissions (ORNL, 2014; IRCP, 2020; USEPA, 2019). Materials will be buried 1.5 m below ground surface and covered with native soil reduce direct contact risks and providing suitable radiological exposure barriers. An assessment of material has been completed by a suitably qualified person for nearby offset wells, and recommendations in line with the National Environmental Protection (Assessment of Site Contamination) Measures 1999, as amended in 2013 (NEPM) on the acceptability of constituents and NORM provided against the human health and ecological criteria. The final assessment report, disposal location and disposal methodology will be certified by an independent suitably qualified third party that: The material is of acceptable quality for disposal to land by the proposed method. Environmental harm will not result from the activity. The environmental risks associated with the burial method are as low as reasonably practicable, as defined within the EMP. The RDM burial methodology will effectively preclude the potential for long-term direct contact risks associated with other geogenic constituents and residual drilling chemicals in the RDM. The material will be placed at a depth that will not accessible by site workers undertaking site activities such as post hole digging.	I	A	VL	Yes	The residual risk is determined to be 1, ALARP and acceptable. Decision Type A risk selected with good practice control measures applied, using relevant personnel with the knowledge and experience to identify alternative controls.
Potential for impacts on livestock from grazing and incidental ingestion of soil or water.	Impacts to livestock production			III	D	M	Fencing to be maintained during period pit has potential to contain fluids. Fluids to be removed from pit prior to backfilling. RDM will be buried 1.5 m below ground surface and covered with native soil and areas will be mounded to prevent water ponding in the area. Implementing these controls resulted eliminated the exposure pathway for this risk.	I	A	VL		
Impacts on burrowing organisms and soil invertebrates	Impacts to terrestrial organisms and reduction or loss of communities			III	E	H	The most sensitive low trophic terrestrial organisms reside in depths of less than 0.5 m and larger burrowing species reside in depths of less than 1.5 m. RDM will be placed 1.5 m below the natural ground level which is below the deep burrowing depth of some mammals, reducing the risk ranking.	I	B	VL		
Erosion of sump area	Sump area rehabilitation			II	D	L	Burial of the RDM 1.5 m below the natural ground level with native soil backfill will prevent the potential for the salinity of the RDM to induce erosion of the soils. Rehabilitation of the well site area will shape the final grade to be consistent with the landform and slightly raised to prevent run-on. The catchment area of the pit area is sufficiently small such that volumes of runoff generated is negligible. Evidence will be required to demonstrate the backfill scope included track-rolling activities. The site is located outside 1% AEP flood levels, and as such velocities from overland flow during these events, eliminating any scour risk. Implementing these controls eliminated the exposure pathway for this risk.	I	A	VL		
Impacts on vegetation regrowth	Impacts to productivity of soil affecting sump area rehabilitation by native vegetation			III	E	H	Potentially saline RDM materials will be buried 1.5 m below natural ground level and therefore below the water and nutrient rooting depth of typical woodland species of the region. It should be noted, the plant species in the area identified in the EMP are adapted to periods of water scarcity and are considered moderately tolerant to salinity. Infiltration and shallow soil moisture is insufficient to support capillary rise of salts from a depth of 1.5 m. Burial of RDM at 1.5 m reduces the risk rating for this risk. The communities identified within the EMP are located within community 1b (Appendix J) - Corymbia dichromophloia, Eucalyptus leucophloia, Erythrophleum chlorostachys, mid high open woodland, over Acacia calligera, Terminalia canescens, ± Petalostigma pubescens low shrubland, over Triodia bitextura ± Chrysopogon fallax, Sehima nervosum, Aristida contorta, mid high sparse hummock grassland. As per the ecology assessment, this was largely (80-90%) ground to low to mid strata (i.e. grass to shrubs). Given the lack of upper strata, the depth of 1.5m is generally acceptable for mitigating any root system interaction.	I	B	VL		

Risk Event	Potential Impact	Relevant Environmental Factor	Risk Source	Initial Risk Ranking*			RDM Burial Method Controls and Management Measures	Residual Risk Ranking*			Effective Controls	Uncertainty Ranking
				C	L	R		C	L	R		
							Given the disturbance requirements of the RDM burial locations, there is a higher regrowth likelihood of grass and shrubs than trees, in addition to the existing low density of trees that currently exists within the pre-disturbed landscape.					
Leaching to groundwater	Impacts to groundwater supply use by receptor (landholder)	Groundwater Environmental Quality		III	C	L	The sump rehabilitation and RDM burial is proposed within well site locations approved under the EMP. The EMP systematically assesses environmental risks and mitigations required to achieve ALARP risk outcomes for well site locations and would avoid areas with unacceptable shallow groundwater risk, such as springs. The Anthony Lagoon aquifer is the shallowest aquifer with potential receptors within EP 161 at a depth of 98 m (Jibera) and 92m (Newcastle South). An assessment of material has been completed by a suitably qualified person for nearby offset wells, and recommendations in line with the National Environmental Protection (Assessment of Site Contamination) Measures 1999, as amended in 2013 (NEPM) on the acceptability of constituents and NORM provided against the human health and ecological criteria. The final assessment report, disposal location and disposal methodology will be certified by an independent suitably qualified third party that: The material is of acceptable quality for disposal to land by the proposed method. Environmental harm will not result from the activity. The environmental risks associated with the burial method are as low as reasonably practicable, and in accordance with the EMP.	II	A	VL		
Potential interactions with surface water in inundation areas	Impacts to aquatic organisms in surface water environment	Surface Water Environmental Quality		II	D	L	The sump rehabilitation and RDM burial is proposed within the well pad locations approved under the EMP and are not located within ephemeral creeks and outside the 1% AEP flood inundation area. The EMP systematically assesses environmental risks and mitigations required to achieve ALARP risk outcomes for well site locations, avoiding areas with unacceptable surface water or inundation risks. The materials will be buried at depth eliminating direct interaction between the RDM and surface water or overland flow. Implementing these controls eliminated the exposure pathway for this risk.	I	A	VL		

Appendix G – Certification of Residual Drilling Material Burial Methodology

Friday, 14 November 2025



Our Ref: Z25.013-LRP-TPR-001_0

(08) 6162 8980

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Brisbane QLD 4000

PO Box 437, Leederville, WA 6903
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ATTENTION: Ben Lippett

SUBJECT: THIRD PARTY CERTIFICATION OF THE ON-SITE BURIAL METHOD FOR RESIDUAL DRILLING MATERIAL AT TWO NEW PROPOSED WELL PADS (NEWCASTLE SOUTH AND JIBERA SOUTH) IN EXPLORATION PERMIT (EP) 161, NORTHERN TERRITORY.

Dr. David Reynolds of Western Environmental Pty Ltd (WEPL) was commissioned by Santos QNT Pty Ltd (Santos) to undertake an independent third-party review and certification of the proposed method for on-site burial of Residual Drilling Material (RDM) developed for the Beetaloo Appraisal Pilot Environment Management Plan (EMP).

Project Background

Santos is an interest holder and operator of Exploration Permit (EP) 161 located in the Beetaloo Sub-basin, approximately 350 km south-east of Katherine in the Northern Territory (NT). Santos has progressively carried out exploration and appraisal activities within EP161 since 2013, including previous drilling, monitoring and testing activities at the Mount Brown (formerly Tanumbirini) well pad, (Santos, 2025b).

Santos is currently preparing an EMP for the Beetaloo Appraisal Pilot, which comprises drilling and testing up to 12 petroleum appraisal wells at two new well pad locations within EP161. The EMP is being prepared to meet the requirements set out in the *Petroleum (Environment) Regulations 2016* (PER Regulations) and demonstrate that all environmental impacts and risks associated with the proposed activity are reduced to a level that is as low as reasonably practicable and acceptable. The EMP must be reviewed and approved by the Minister for Environment before the proposed activities can commence. Once approved, the EMP is legally enforceable and will be used by the environmental regulator to monitor performance against the environmental outcomes (as set out in the EMP).

The proposed new well pads are identified as Newcastle South and Jibera South and will be located on Tanumbirini Station (a cattle grazing property) within NT Portion 701 of Arnold. Each well pad will include evaporation tanks, storage tanks, drilling cutting and fluid pits/sumps, a flare, laydown areas, maintenance workshops, berms and diversion banks, drainage and sediment control infrastructure, and associated transfer pipework. The well pads will be rehabilitated following the decommissioning and removal of the infrastructure in accordance with the approved EMP, (Santos, 2025b).

The proposed activities are estimated to commence in April 2026 and will be progressively undertaken over a period of approximately 5 years, (Santos, 2025b).

It is noted that the Beetaloo Appraisal Pilot EMP will include previously authorised and ongoing regulated activities undertaken by Santos within EP161 to enable Santos to operate under a single EMP.

Purpose

The purpose of this document is to present the key findings from the third-party review and certify the proposed method for on-site burial of RDM in accordance with clause C.4.1.2(f) of the *Code of Practice: Onshore Petroleum Activities in the Northern Territory* (the Code). It is understood that this certification will form part of EMP approval process.

It should be noted that this certification applies only to the **proposed RDM burial method** given that works at the new well pads have not commenced and RDM has not yet been generated (as of November 2025). It is anticipated that additional certifications of the RDM generated at the Newcastle South and Jibera South well pads will not be required provided the material is assessed and managed in accordance with the approved EMP. Future certification may be required for any RDM proposed for disposal to land that does not comply with the specifications and requirements set out in the approved EMP.

Objectives

The objective of this independent third-party review is to demonstrate that the method for on-site burial of RDM, associated with two new well pads proposed within the Beetaloo Appraisal Pilot EMP, reduces environmental risks to a level as low as reasonably practical and will not result in environmental harm.

Scope of Work

The scope of work for this third-party review included:

- A review of the documents listed in Table A.
- Preparation of a certification letter (this document).

Table A: Review Documents

Reference	Document Title & Number	Version	Date	Format Provided
Primary Document¹				
Santos, 2025a	Wastewater Management Plan	Final	14-Nov-25	.docx
Other Supporting Documents²				
Santos, 2025b	Beetaloo Appraisal Pilot Environment Management Plan	Final	14-Nov-25	.docx
EHS Support, 2025	EP 161 – McArthur Appraisal Hydraulic Fracturing Fluid System, Drilling Fluid and Cementing Chemicals - Chemical Risk Assessment	-	2-Jun-25	.pdf
Santos, 2025c	Appendix E – Spill Management Plan	Final	14-Nov-25	.docx
Fyfe, 2025	EP161 – Jibera South and Newcastle South Erosion and Sediment Control Plan, 20021-70	0	25-Jun-25	.pdf

Reference	Document Title & Number	Version	Date	Format Provided
Santos, 2025d	Appendix K – Rehabilitation Management Plan	Final	14-Nov-25	.docx
WRM, 2025	Design 1 in 1,000 rainfalls and freeboard - EP161, 1413-80-B3	-	1-Jul-25	.pdf
Santos, 2024	Tanumbirini Residual Drilling Material Burial Method	1	27-Jun-24	.pdf
EHS Support, 2024	EMP EP 161 Residual Drilling Material Risk Assessment, Tanumbirini 2H and 3H, EP161	0	20-Aug-24	.pdf
Santos, 2025e	Area Number 1052 – EP161, Newcastle South – McArthur Appraisal Site Plot Plan Layout Drawing No. 1052-040-LDD-0001	1	17-Oct-25	.pdf
Santos, 2025f	Area Number 1052 – EP161, Newcastle South – McArthur Appraisal Civil and Erosion & Sediment Control Layout Drawing No. 1052-040-LDD-0002	1	17-Oct-25	.pdf
Santos, 2025g	Area Number 1052 – EP161, Jibera South – McArthur Appraisal Site Plot Plan Layout Drawing No. 1052-040-LDD-0003	1	17-Oct-25	.pdf
Santos, 2025h	Area Number 1052 – EP161, Jibera South – McArthur Appraisal Site Plot Plan Layout Drawing No. 1052-040-LDD-0004	1	17-Oct-25	.pdf

Notes:

1. The primary document that presents the proposed on-site burial method for RDM at the two new well pads (Jibera South and Newcastle South).
2. Other documents that were reviewed to provide further context and supporting information with respect to the environmental risk posed by RDM.

Limitations

The following limitations apply to the scope of work:

- RDM has not yet been generated at the proposed new well pads and the proposed on-site burial methodology for RDM and supporting risk assessment have been based on data obtained from RDM generated at the nearby Mount Brown well pad (i.e., an offset well pad). Site-specific conditions (i.e., hydrogeology and geochemistry) and the characteristics of (future) RDM at Jibera South and Newcastle South need to be confirmed in accordance with the framework specified in the approved Wastewater Management Plan (WWMP).
- This certification of the proposed on-site burial method for RDM at the Jibera South and Newcastle South well pads is subject to the future assessment of RDM by a Suitably Qualified and Competent Professional (SQCP) in accordance with clause C.4.1.2(c) and C.4.1.2(e) of the Code and confirmation that the material complies with the specifications in the approved WWMP.
- Deviations from the RDM assessment, management and on-site disposal methodology specified in the approved WWMP may require additional certification from a suitably qualified third party in accordance with C.4.1.2(f) of the Code.

Legislative Framework

Environment protection requirements for petroleum exploration and production activities in the NT are established through the *Petroleum Act 1984* and the PER Regulations.

This third-party review also considered additional legislation and guidelines as they pertain to the management and disposal of listed/controlled wastes and assessment of contaminated land. The additional legislation and guidelines considered during this review are listed in Attachment A.

Key Definitions

The legislative definitions of key terms used in clause C4.1.2 of the Code are as follows:

- **Drilling fluids** (clause C.4.1.1 of the Code) – contain the original fluid, some formation fluids and cuttings of the formation being drilled and other materials used in well drilling activities (e.g., cement, bentonite clay, etc.). Drilling fluids can have a substantial volume of solids derived from additives and drill cuttings. Management of drilling fluid as a waste must manage the liquid and solid components appropriately.
- **Environment** (s6 of the *Environment Protection Act 2019*) – all aspects of the surroundings of humans including physical, biological, economic, cultural and social aspects.
- **Environmental harm** (s7[1] of the *Environment Protection Act 2019*) – direct or indirect alteration of the environment to its detriment or degradation, of any degree or duration, whether temporary or permanent.
- **Waste** (s4 of the *Waste Management and Pollution Control Act 1998*) – a solid, liquid or gas, or a mixture of such substances, that is or are left over, surplus or an unwanted by-product from any activity (whether or not the substance is of value) and includes a prescribed substance or class of substances.

Review Outcomes

The findings from the third-party review of the proposed method for on-site burial of RDM associated with two new well pads (yet to be constructed) within EP161 are:

- The environmental setting and layout of the proposed Jibera South and Newcastle South well pads has been appropriately characterised within the Beetaloo Appraisal Pilot EMP for the purposes of informing a Conceptual Site Model (CSM).
- A CSM for the proposed new well pads is presented in Appendix C of the WWMP (Santos, 2025a). The CSM has been based on existing data for RDM at the Mount Brown (formerly Tanumbirini) well pad, which is located within EP161 and considered to be representative of the material that will be generated at Jibera South and Newcastle South. The CSM is generally consistent with the *National Environment Protection (Assessment of Site Contamination) Measure 1999*, as amended 2013 (ASC



NEPM) and presents contaminants of potential concern, potential human and ecological receptors that may be at risk from buried RDM, and potential pathways and exposure scenarios.

- An assessment of potentially complete source-pathway-receptor linkages has been completed as part of the CSM and exposure to volatile contaminants and radiological emissions associated with the buried RDM were identified as the risk-driving pathways (based on residual risks after implementation of mitigation measures). The potentially impacted receptors were identified as agricultural and gas field workers, visitors and recreational users, grazing animals, avian species and burrowing organisms.
- A risk assessment for the on-site burial of RDM at the new well pad sites is presented in Appendix F of the WWMP (Santos, 2025a). Potential environmental impacts have been identified and assessed with consideration of the CSM and proposed mitigation measures. The residual risk ranking for each potential environmental impact was assessed to be 'very low'. The risk assessment demonstrates that the proposed mitigation measures will reduce the environmental risk posed by on-site burial of RDM to a level as low as reasonably practicable.
- The CSM and risk assessment are supported by a chemical risk assessment (EHS Support, 2025) of the fluids and chemicals that will be used during the regulated activities, which is included as Appendix D to the EMP. The chemical risk assessment did not identify elevated risks or unacceptable exposures.
- It is acknowledged that the CSM and risk assessment have been based on existing data for a separate site and may require future updates once site-specific data has been obtained. Any required updates to the CSM and risk assessment for Jibera South and/or Newcastle South should be addressed within a future Sampling Analysis and Quality Plan (SAQP) and risk assessment report prepared by a SQCP for the RDM.
- The WWMP (Santos, 2025a) outlines the process for assessing RDM at the proposed Jibera South and Newcastle South well pads. The overall approach is generally consistent with the on-site RDM burial method applied at the Mount Brown well pad, as outlined within the Santos (2024) Tanumbirini Residual Drilling Material Burial Method. The on-site burial of RDM at the Mount Brown well pad was previously certified in accordance with clause C.4.1.2 of the Code.
- The on-site RDM burial method for Jibera South and Newcastle South specified within the WWMP (Santos, 2025a) includes:
 - Sampling and analysis of the RDM in accordance with the Code and ASC NEPM to confirm that the material is of acceptable quality for disposal to land and environmental harm will not result from the activity. The analytical requirements for RDM samples are specified in Appendix D of the WWMP. The WWMP acknowledges that the RDM sampling program at each well pad will be developed and implemented under the oversight of a SQCP.



- Assessment of environmental impacts and risks posed by the RDM to confirm that the proposed burial method and mitigation measures will reduce the risk to a level as low as reasonably practicable (clause C.4.1.2(c) of the Code). This assessment will be undertaken by a SQCP and include:
 - A review of the RDM analytical results (for Jibera South and Newcastle South) against the adopted screening criteria specified in Appendix E of the WWMP to confirm the CSM (Appendix C) and risk assessment outcomes (Appendix F).
 - A review of the site-specific environmental setting (i.e. geology and hydrogeology) and exposure pathway analysis to confirm the CSM (Appendix C) and risk assessment outcomes (Appendix F).
 - Confirmation that the thickness of low permeability claystone/siltstone overlying the upper regional aquifer is greater than 50 m or is sufficient to restrict the water infiltration such that the risk of contaminants reaching groundwater is as low as reasonably practicable.
 - Confirmation that the Jibera South and Newcastle South RDM complies with the framework specified within the WWMP (including this certification) and is of acceptable quality for disposal to land and the on-site burial method will not cause environmental harm.
- Construction of burial pits within the operational footprint of the well pad, including as-constructed surveys. Each burial pit is proposed to be 2,400 m² and at least 3 m deep and will be constructed outside the 1% Annual Exceedance Probability (AEP) inundation (flood) extent.
- Transfer the RDM to the burial pits and spread evenly across the base of each pit to create a level surface. Survey the placed RDM to confirm that the cover thickness will be greater than 1.5 m relative to the final land surface. It is acknowledged that standing liquids are to be removed and separated from the RDM prior to transfer to the burial pit.
- Backfill each burial pit with at least 1.5 m of clean cover material (i.e., native soils excavated during construction of the burial pit). Track roll and compact the cover material ensuring that the final surface of the reinstated pit is slightly mounded with a camber of 0.5% to 1.0% to shed water and allow minor settling over time.
- Documentation and recording keeping to demonstrate compliance with the Code and approved EMP.
- Separate certification by a suitably qualified third-party of any RDM proposed for disposal to land that does not comply with the contaminant screening methodology and management and disposal requirements specified in the WWMP.



- It is acknowledged within the WWMP (Santos, 2025a) that if the RDM is found to be unsuitable for burial within EP161, the material will be classified and removed from the well pad site for off-site disposal at an appropriately licenced facility in accordance with the *Waste Management and Pollution Control Act 1998* (WMPC Act).
- All other wastes generated during the regulated activities at each well pad will be removed for off-site disposal at an appropriately licenced facility in accordance with the WMPC Act. No other wastes or materials are proposed to be disposed to land at the Jibera South or Newcastle South well pads.

Certification Statement

I, Dr. David Reynolds, am a suitably qualified person registered under s68 of the WMPC Act, and am not an employee of, nor have a financial interest or any involvement that would lead to a conflict of interest with the interest holder(s) of EP161.

Overall, I am satisfied that the proposed on-site burial method for RDM at the new well pads described within the WWMP (Santos, 2025a) aligns with the intent of clause C.4.1.2 of the Code and the PER Regulations and demonstrates that environmental impacts and environmental risks will be reduced to a level that is as low as reasonably practicable. Provided that the material is assessed by a SQCP and managed in accordance with framework specified in the WWMP (Santos, 2025a), the material will be suitable for disposal to land and environmental harm is unlikely to result from the on-site burial of RDM at the Jibera South and Newcastle South well pads.

However, any RDM that does not comply with the specifications in the WWMP (Santos, 2025a) may require separate certification under C.4.1.2(f) of the Code.

This certification letter should be read in conjunction with the Schedule: Statement of Limitations. Should you have any queries regarding the above, please contact the undersigned on (08) 6162 8980.

Yours sincerely,
Western Environmental Pty Ltd



Dr. David Reynolds
Senior Principal Engineer

Schedule: Statement of Limitations

Attachment A: Additional Legislation and Guidelines



SCHEDULE: Statement of Limitations

Statement of Limitations

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Scope of Services

This independent third-party review and certification letter report ("this report") has been prepared solely for the purpose stated in this report and in accordance with the scope of work ("agreed scope").

WEPL disclaims any and all liability with respect to any use of or reliance upon this report for any other purpose whatsoever.

In particular, it should be noted that this report is based on a scope of services defined by Santos QNT Pty Ltd (the Client), and is limited by the information supplied by the Client (and its agents) and, in some circumstances, access and/or site disturbance constraints.

The scope of services did not include any assessment of the title to, or ownership of the properties, buildings and structures referred to in this report, or the application or interpretation of laws in the jurisdiction in which those properties, buildings and structures are located.

Reliance on Data

In preparing this report, WEPL has relied on data, surveys, analyses, designs, plans and other information provided by the Client (or its agents), other individuals and organisations ("the data").

Except as otherwise stated in this report, WEPL has not verified the accuracy or completeness of the data. WEPL does not represent or warrant that the data is true or accurate, and disclaims any and all responsibility or liability with respect to the use of the data.

To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in this report ("conclusions") are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data.

WEPL does not accept any responsibility for and disclaims all liability to the Client and any other person for any incorrect or inaccurate conclusions resulting from or affected by any data being incorrect, inaccurate or incomplete or if any relevant information or matter has been concealed, withheld, misrepresented or otherwise not fully disclosed to WEPL.

The reliability of the conclusions is also limited by the Agreed Scope (including any constraints or limitation therein) and the methods used to carry out those services, both of which are as stated or referred to in this report. WEPL disclaims any liability for any inaccuracies in the conclusions resulting from or affected by any of those matters.



Environmental Conclusions

WEPL has not conducted environmental field monitoring and/or testing in the preparation of this report. The nature and extent of monitoring and/or testing conducted other parties is described in the data provided by the Client (or its agents).

On all sites, varying degrees of non-uniformity of vertical and horizontal conditions in media (soil, water, air, waste or other media) are encountered. Hence no monitoring, common testing or sampling technique can eliminate the possibility that monitoring or testing results/samples are not totally representative of media conditions encountered. The conclusions are based on the data and the environmental field monitoring and/or testing actually undertaken, and are therefore merely indicative of the environmental condition of the site at the time of preparing this report, including the presence or otherwise of contaminants or emissions. It should be recognised that site conditions, including the extent and concentration of contaminants, can change.

Within the limitations imposed by the Agreed Scope, the preparation of this report has been undertaken and performed in a professional manner, in accordance with generally accepted practices and using a degree of skill and care ordinarily exercised by reputable environmental consultants under similar circumstances. To the maximum extent permitted by law, no other warranty, express or implied, is made.

Report for Benefit of Client

WEPL disclaims all liability or responsibility whatsoever to any person or organisation other than the Client in respect of any use of or reliance upon this report. Reliance on this report by any person or organisation other than the Client is expressly prohibited.

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Parties and organisation other than the Client should not rely on this report or the accuracy or completeness of any conclusions contained in this report, and should make their own enquiries and obtain independent advice in relation to such matters.

Other Limitations

This report is intended to be read and considered in its entirety, and sections or parts of this report therefore must not be read and relied on out of context.

WEPL will not be liable to update or revise this report to take into account any events or circumstances or facts becoming apparent after the date of this report.



ATTACHMENT A: Additional Legislation and Guidelines

Environment Protection Act 2019 (EP Act).

Environment Protection Regulations 2020 (EP Regulations).

Radiation Protection Act 2004 (RP Act).

Radiation Protection Regulations 2007 (RP Regulations).

Waste Management and Pollution Control Act 1998 (WMPC Act).

Waste Management and Pollution Control (Administration) Regulations 1998 (WMPC Regulations).

National Environment Protection Council (NEPC). 2013. *National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended 2013*. Commonwealth of Australia. 22 May 2013 (ASC NEPM).

Australian Radiation Protection and Nuclear Safety Agency (ARPANSA). 2021. *National Directory for Radiation Protection – 2nd Edition*. Commonwealth of Australia. October 2021.

ARPANSA. 2020a. *Code for Radiation Protection in Planned Exposure Situations*. Radiation Protection Series C-1 (Rev. 1). Commonwealth of Australia. January 2020.

ARPANSA. 2020b. *Guide for Classification of Radioactive Waste*. Radiation Protection Series G-4. Commonwealth of Australia. 2020.

ARPANSA. 2018a. *Code for Disposal Facilities for Solid Radioactive Waste*. Radiation Protection Series C-3. Commonwealth of Australia. October 2018.

ARPANSA. 2018b. *Code for the Disposal of Radioactive Waste by the User: Levels for disposal and discharge of radioactive waste by the user to landfill, sewer and the atmosphere*. Radiation Protection Series C-6. Commonwealth of Australia. September 2018.

ARPANSA. 2015. *Radiation Protection of the Environment*. Guide G-1. Commonwealth of Australia. November 2015.

ARPANSA. 2008. *Management of Naturally Occurring Radioactive Material (NORM)*. Radiation Protection Series Publication No. 15. Commonwealth of Australia. August 2008.

ARPANSA. 2005. *Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing*. Radiation Protection Series Publication No. 9. Commonwealth of Australia. August 2005.

NT Government. 2025. *Code of Practice: Onshore Petroleum Activities in the Northern Territory*. Version 3. 19 February 2025 (the Code).

NT Government. 2022. *Environment Management Plan Content Guideline, Onshore Petroleum Regulated Activities*. NTEPA2015/0088-024~0002. Version 1.1. Petroleum Legislation and Policy Unit. 19 August 2022.



Northern Territory Environment Protection Authority (NT EPA). 2025a. *Guidelines for the Siting, Design and Management of Solid Waste Disposal Sites in the Northern Territory*. 33-D25-12152. Version 1.1. July 2025.

NT EPA. 2025b. *NT EPA Environmental factors and objectives*. NTEPA2019/0141-010~0011. Version 4.0. 17 March 2025.

NT EPA. 2017. *Northern Territory Contaminated Land Guideline*. Version 1.0. June 2017.

Department of Health (DOH). 2025. *Contaminated sites, Ground and surface water, Chemical screening guidelines*. Government of Western Australia.

Department of Water and Environmental Regulation (DWER). 2021. *Assessment and management of contaminated sites*. Government of Western Australia. November 2021.

DWER. 2019. *Landfill Waste Classification and Waste Definitions 1996 (as amended 2019)*. Government of Western Australia. December 2019.

Environmental Health Standing Committee (enHealth). 2012. *Environmental Health Risk Assessment, Guidelines for assessing human health risks from environmental hazards*. Commonwealth of Australia. June 2012.

