Waste Facility Decommissioning & Closure Plan

TELLUS

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SANDY RIDGE FACILITY WASTE FACILITY DECOMMISSIONING AND CLOSURE PLAN

Draft Report |August 2016

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DISTRIBUTION

Report File Name	Report Status	Author	Date	Distribution
Waste Facility Decommissioning and Closure Plan – V0.1	V0.1 (Draft)	Aurora Environmental	24 December 2015	Tellus Holdings Ltd
Waste Facility Decommissioning and Closure Plan – V0.2	V0.2 (Draft)	Aurora Environmental	18 April 2016	Tellus Holdings Ltd

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ABBREVIATIONS

AHD	Australian Height Datum
AWS	Automated weather station
BGL	below ground level
DER	Department of Environment Regulation
dS/cm	deciSiemens per centimeter
DPAW	Department of Parks and Wildlife
EC	electrical conductivity
EILs	ecological investigation levels
EMS	Environmental management system
EPA	Environmental Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
ha	hectare
ICP	institutional control period
IWDF	Intractable waste disposal facility
km	kilometres
kL	kilolitres
km/hr	kilometre per hour
L	litres
L/s	litres per second
m	metre
meq/100g	milliequivalent of hydrogen per 100g of dry soil
mg	milligram
mg/kg	milligram per kilogram
mg/L	milligrams per litre

MMDD	maximum modified dry density
mm/day	millimetres per day
mm/hr	millimetres per hour
m/s	metres per second
MCP	Mine Closure Plan
PER	Public Environmental Review
TDS	total dissolved solids
SMDD	standard modified dry density
t	tonne
TDS	total dissolved solids
WC Act	*Wildlife Conservation Act 1950* (WA)
WFDCP	Waste Facility Decommissioning and Closure Plan

1 INTRODUCTION

The decommissioning and long–term closure of a Class V waste disposal facility is a pioneer activity in Australia and there are few references at international level to provide guidance on appropriate practice. Tellus Holdings Ltd (Tellus) has prepared this Waste Facility Decommissioning and Closure Plan (WFDCP) to propose decommissioning and closure activities for the Sandy Ridge Project (herein referred to as the 'Facility').

The design and planning is based on the foundation that safety of people is of paramount importance and equally important is the minimisation of risks on the environment for geological time (10,000 years +).

1.1 Purpose and objective

The purpose of this WFDCP is to provide regulators and the community with an outline of the decommissioning and closure activities proposed for the Facility.

The objective of the WFDCP is to provide a decommissioning procedure and a passive management regime which will ensure that there is minimal risk of the release of contaminants (chemical or radioactive) into the surrounding environment or being disturbed by either natural process or anthropogenic activities.

1.2 Scope

Tellus has prepared two closure plans for Sandy Ridge. The two plans address the closure requirements for the two key components of the proposal as described below:

- **Mining** – information relating to mine closure for tenement relinquishment is outlined in the Mine Closure Plan (MCP) required under the *Mining Act 1978* (WA).
- **Waste Cells** – information relating to the waste cells is set out in the WFDCP (this document).

The elements of the Sandy Ridge Project that are covered in this WFDCP are listed in Table 1–1.

Table 1-1 Elements of the Sandy Ridge Project and location of information regarding decommissioning and closure

PHYSICAL ELEMENTS	MCP	WFDCP
Class V/Class IV cell closure	X	✓
Front gate office and amenity building	X	✓
Water pipeline	X	✓
Roof canopy	X	✓
Underground storage area	X	✓
Radioactive waste warehouse	X	✓
Accommodation camp	✓	X
Class II landfill	✓	X
Internal roads	✓	X

PHYSICAL ELEMENTS	MCP	WFDCP
Waste inspection area	✓	X
Container hardstand	✓	X
Weighbridge	✓	X
ROM pad	✓	X
Diesel fuel tank, piping reticulation and bowser	✓	X
Waste laboratory	✓	X
Kaolin laboratory	✓	X
Kaolin processing plant	✓	X
Washdown pad and washdown treatment and storage system	✓	X
Water tanks	✓	X
Contractors offices, laydown yard and maintenance workshop	✓	X
Kaolin products storage warehouse	✓	X
Saline water ponds	✓	X
Explosive ordinance building	✓	X
Sewage treatment systems	✓	X
LNG facility	✓	X
Switchroom and generators	✓	X

1.2.1 Phases of Facility closure

The phases of management for closure of the Facility are illustrated in Figure 1–1 below.

Figure 1–1 Phases of closure

Years 0 to 25: Operations Phase

- Tellus Holdings Ltd manage the waste facility.
- Complete backfill, cap cells, replace topsoil and establish vegetation.
- Undertake subsidence, radiation, vegetation and groundwater monitoring.

Years 26 to 45: Post Closure Management Period

- Tellus Holdings Ltd manage the waste facility.
- Manage any subsidence of caps, and infill plant vegetation.
- Undertake subsidence, radiation, vegetation and groundwater monitoring.

Years 46 to 325 (or end date as negotiated with regulator): Institutional Control Period

- State Government manage the waste facility and restrict public access.
- Undertake radiation and groundwater monitoring.

1.3 Location and layout of the facility

The Sandy Ridge Project is located approximately 75 kilometres (km) north-east of Koolyanobbing, in the Goldfields region of Western Australia (Figure 1–2). Access is via a 100 km road to the Mount Walton East Intractable Waste Disposal Facility (IWDF) (Crown Reserve No. 44102) that extends northward from Great Eastern Highway; a 4.5 km portion of a westward access road extending towards Mount Dimer and a 5.3 km dedicated site access road extending northwards to the mining lease (Figure 1–3).

1.4 Ownership

The land is vacant Crown Land. Tellus received advice that the best approach to providing suitable tenure for the site is for Department of Lands to lease the land under a Crown Lease. This land will then be leased to Tellus for a period to be agreed (currently expected to be years 0 to 56).

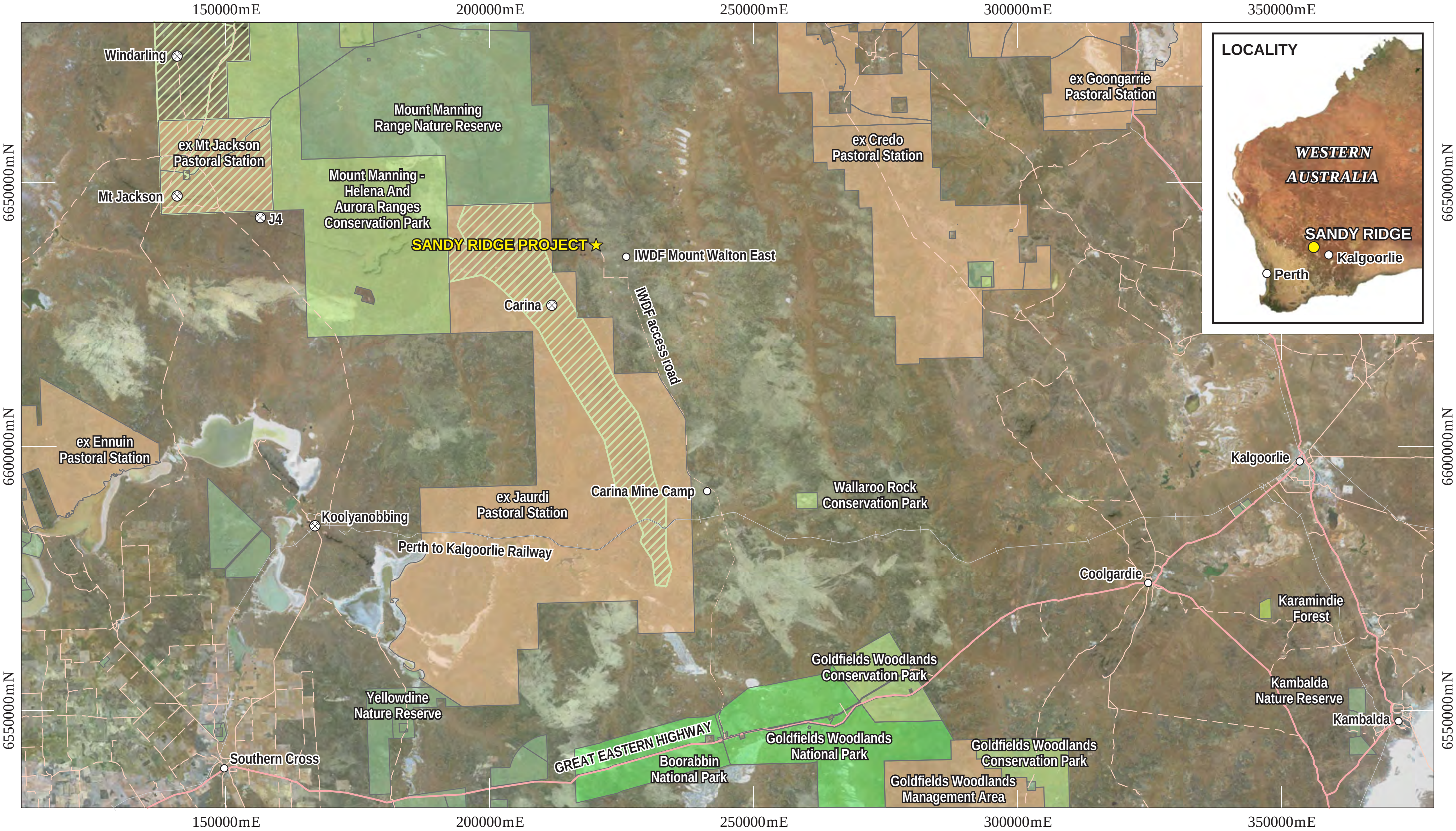
1.5 Review

The WFDCP is a 'live' document, with gaps in information to be filled as the proposal progresses through the design/planning stage to the construction and operations phase.

This WFDCP will be reviewed and revised as appropriate by Tellus every three years or such other time as specified in writing by the Environmental Protection Authority (EPA) or Department of Environment Regulation (DER). The next review date is anticipated to be as soon as possible following Ministerial Approval in order to include relevant conditions or requirements regarding closure.

Next Review:

As soon as possible following Ministerial Approval in order to include relevant conditions or requirements regarding closure.



Legend:
- Iron Ore Mine
- Rail
- Major Road
- Minor Road

DPaW Managed Lands:
- Conservation Park
- Former Leasehold
- National Park
- Nature Reserve
- Proposed Conservation and Mining Reserve
- State Forest

Client: TELLUS

N

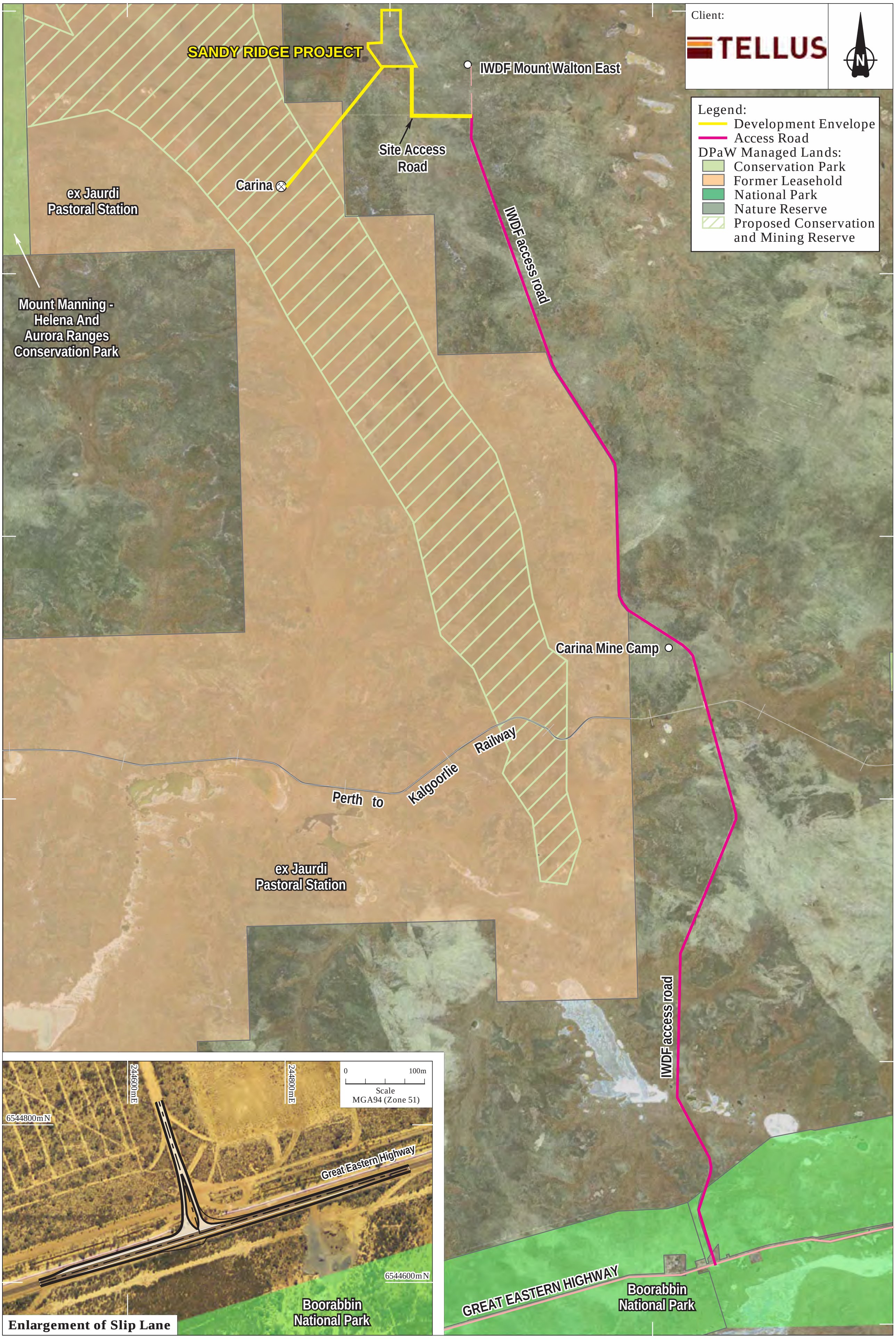
0 20km
Scale 1:1,000,000
MGA94 (Zone 51)
CAD Ref: g2294_PER_01_01.dgn
Date: Jan 2016 | Rev: H | A4

Aurora environmental

Author: C. Dorrington | AE Ref: THO2014-003
Drawn: CAD Resources ~ www.cadresources.com.au
Tel: (08) 9246 3242 ~ Fax: (08) 9246 3202

Sandy Ridge Project
Regional Location
Public Environmental Review

Figure: **1-2**



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Sandy Ridge Project

Access to Sandy Ridge

Public Environmental Review

Figure: **1-3**

2 CLOSURE OBLIGATIONS AND COMMITMENTS

2.1 Legal obligations register

All legal obligations relevant to rehabilitation and closure of cells at the Facility are identified in the Legal Obligations Register (Table 2–1). Note: this register will be updated following receipt of environmental approvals.

Table 2-1 Legal obligations register

Ministerial Statement (No and Date)		
Condition No	**Condition**	
Works Approval (No and Date) Relates to Tenement No: XX		
Condition	**Aspect Related to Closure**	
***Environmental Protection Act 1986* Licence No:**	**Category:**	
Condition	**Aspect Related to Closure**	

3 STAKEHOLDER ENGAGEMENT

Tellus recognise the importance of engaging with stakeholders for the Facility closure planning, to achieve acceptable environmental outcomes, manage stakeholder expectations and eliminate or avoid potential risks associated with closure.

3.1 Stakeholder identification

'Stakeholders' are defined as both internal and external parties who are likely to affect, to be affected by or to have an interest in closure planning and outcomes. The stakeholders for the Facility are:

Internal

- The Tellus Board and Corporate Executive
- Project Leader – Michael Ingram
- Environment & Approvals Manager – Richard Phillips

External

- Institutional control period (ICP) government manager – To be confirmed.
- Environmental Regulators – Western Australian DER, currently represented by Manager Licensing Waste Industries (North), Commonwealth Department of the Environment, Department of Health (Radiation Safety Branch).
- Ex–Jaurdi pastoral lease land manager – Western Australian Department of Parks and Wildlife (DPAW), currently represented by Area Manager North and Goldfields.
- Other interested government agencies – Department of Mines and Petroleum, Department of Water, and Department of Health (Environmental Health Branch).
- Local Government – Shire of Coolgardie, represented by the Chief Executive Officer.
- Local community members or groups.
- Interested Non–government organisations.
- Adjacent Landholders – Department of Finance, Building Management and Works Branch – manager of the Mount Walton East IWDF and IWDF access road.
- Adjacent Landholders – Department of Lands (for vacant crown land) and DPAW for lands vested in them (e.g. former Jaurdi Pastoral lease).
- Mineral Resources – Operator of the Carina Iron Ore Mine.

3.2 Stakeholder engagement register

A summary of stakeholder engagement in relation to closure of the Facility is listed in Table 3–1. This engagement register will be updated every three years during scheduled reviews of this document.

Table 3-1 Stakeholder engagement register

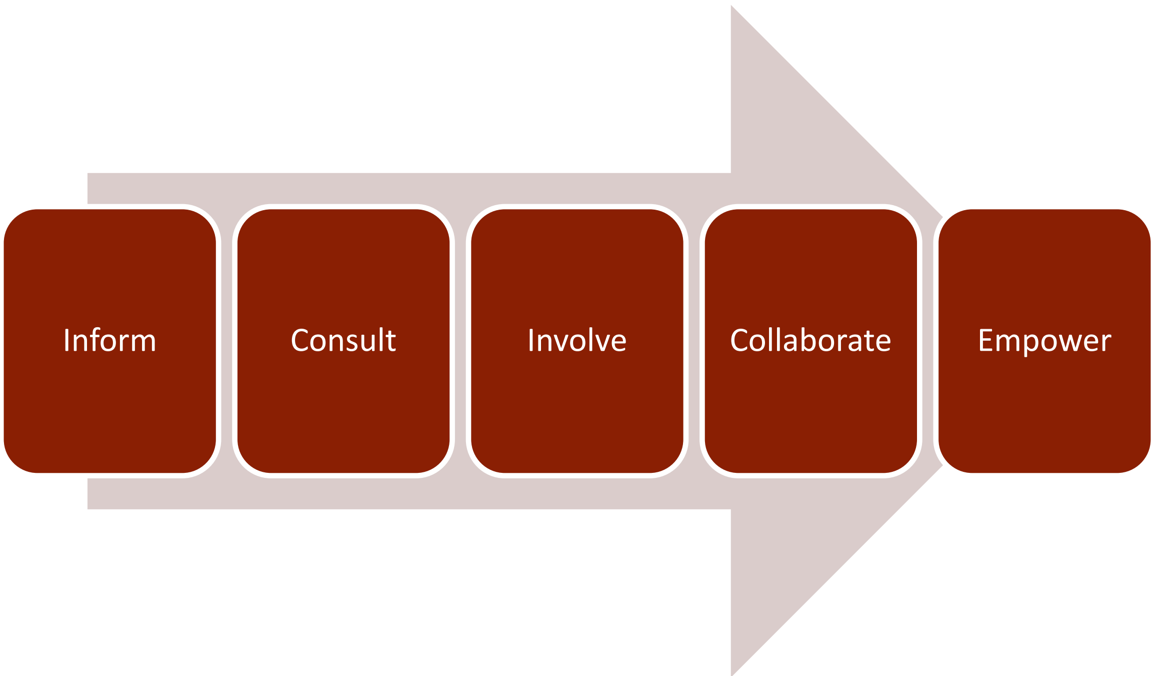
Stakeholder	CONSULTATION DATE	CONSULTATION METHOD	STAKEHOLDER COMMENTS/ISSUE	TELLUS RESPONSE	STAKEHOLDER RESPONSE
DMP (Environmental Branch – Team Leader Minerals Kalgoorlie) and DER (Manager Waste North and Senior Environmental Officer)	19 November 2015	Meeting	• Consider if a 10 year subsidence monitoring is appropriate for the Sandy Ridge Project. • The Mine Closure Plan and Waste Facility Closure and Decommissioning Plan should both outline Tellus' position on revegetation of the surface of the domed clay cap. • Waste Facility Closure and Decommissioning Plan will include a commitment for review of the document every 3 years. • The Mine Closure Plan and Waste Facility Closure and Decommissioning Plan should both outline Tellus' position on fencing and how maintenance is ensured long-term.	These items have been considered in this WFDCP.	The justification for a 10 year subsidence monitoring program is provided in Section 7. Vegetation establishment is described in Section 7. The requirement for a 3 yearly review of this document is incorporated into Section 1.5. Fencing is described in Section 7.

3.2.1 Stakeholder engagement strategy

Purpose of Communication

For closure to be effective, engagement with stakeholders is required at every phase of the Sandy Ridge Project. The Community Engagement and Development Handbook (DITR, 2009) outlines two frameworks generally implemented by miners to engage with the community and stakeholders. Tellus considers the International Association of Public Participation (IAP2) process (illustrated in Figure 3–1) as the appropriate framework for the Sandy Ridge Project, as it allows for a continuum of consultation with stakeholders.

Figure 3–1 Continuum of engagement



Tellus has interpreted the purpose of each type of engagement in Plate 2 as described below:

- **Inform** – providing information about the Facility.
- **Consult** – direct conversation on specific areas of risk and opportunity in relation to closure.
- **Involve** – interactive mode between Tellus and the stakeholder to achieve a common closure outcome.
- **Collaborate** – Stakeholder-driven consultation on aspects of closure.
- **Empower** – participation in planning and decision-making, not only on issues related to operational impacts, but also on decisions regarding the community’s future once the Facility has closed.

In the initial stages of closure planning, Tellus is most likely to inform stakeholders of the plans for closure. As the Facility develops and is operational, there will be a move towards the consult, involve and collaborate forms of engagement. Nearing the end of the Facility life, there may be opportunities to empower stakeholders. The appropriate purpose of communication will be evaluated during each engagement event, and reflected upon during the three yearly review of this document.

Methods of Communication

A single or multiple methods may be used to communicate with stakeholders, depending on the purpose of the communication. Several methods are listed in Table 3–2.

Table 3-2 Communication methods

Purpose	Method
Inform	information booths, media releases, newsletters, brochures, mail out programs, websites and hotlines.
Consult	Public meetings, discussion groups, polls, surveys and focus groups.
Involve and Collaborate	Workshops and discussion groups, learning circles, interviews, reference groups and community consultative committees.
Empowerment	Site visits, direct phone calls and electronic mail.

Targeted Communication

The consultation to be undertaken prior to the submission of the next revision of this WFDCP includes:

1. Discussions internally within Tellus to agree on any required changes to the document.
2. Tellus will consult with each external stakeholder to gain feedback.
3. The list of required changes will be discussed with all external stakeholders with the aim of achieving agreement.
4. Once agreed, Tellus will make the changes to the document.

The revised document will be issued to all external stakeholders for comment, and their comments considered in a newer version.

Documentation

All stakeholder engagement, regardless of purpose or form, will be recorded in Table 3–1.

4 CLOSURE OBJECTIVES

4.1 Post waste facility land use

The post waste facility land use following the cessation of waste disposal is to leave the site vacant, with Crown Lease tenure in place to ensure no future incompatible activities can occur at this location, due to the presence of buried waste that will not breakdown over time (for example if arsenic trioxide is buried, arsenic will still be present thousands of years later).

The waste cells landform is expected to comprise three areas, of rows of capped cells, as shown in Figure 4–1. The topography will be slightly elevated, approximately 5 m AHD higher than the surrounding landscape. The integration with the surrounding topography is shown in Appendix A.1.

Figure 4–1 Final landform

4.2 Closure objectives

The regulator of a Class V Waste Facility in Western Australia (currently DER) has no published closure requirements for Class V landfill sites, but based on consultation with DER, closure requirements will centre on the post-closure monitoring and management of potential emissions and discharges.

Tellus will also discuss the closure objectives with the ICP government manager.

The closure objectives proposed are:

1. Structurally stable, non-eroding disposal cells.
2. No emissions or discharges from the cells following capping.
3. Establish vegetation on the cell caps.

To demonstrate that closures objectives have been met, Tellus will need to meet the completion criteria outlined in Section 4.3, and provide evidence to regulators as stipulated.

4.3 Completion criteria

4.3.1 Basis for development

Whilst the Sandy Ridge Project is in the conceptual phase of planning, the completion criteria have been developed based on the technical environmental studies completed of the development envelope and an understanding of the criteria for securing intractable and hazardous waste in a near surface repository based on the following guidance:

- *Design, Construction, Operation and Surveillance of Repositories for Solid Radioactive Wastes in Shallow – Ground* (International Atomic Energy Agency, 1984).
- *Classification and Disposal of Radioactive Waste in Australia – Consideration for Near Surface Burial in an Arid Area* (ARPANSA, 2010).
- *Code of Practice for the near-surface disposal of radioactive waste in Australia* (NHMRC, 1992).

Tellus recognise that closure of a near surface repository for geological time is a pioneer activity in Western Australia, and as such there are no published guidelines applicable to the closure of a Class V landfill. In Western Australia, closure activities are frequently associated with mines, and guidelines associated with mine closure are therefore the nearest form of guidance on criteria to be met at closure. Therefore in developing completion criteria for the Facility, Tellus has considered the requirements of the *Guidelines for Preparing Mine Closure Plans* (DMP & EPA, 2015).

Tellus understand that completion criteria should:

- Specific enough to reflect a unique set of environmental, social and economic circumstances.
- Measurable to demonstrate that rehabilitation is trending towards analogue indices.
- Achievable or realistic so that the criteria being measured is attainable.
- Relevant to the objectives that are being measured and flexible enough to adapt to changing circumstances without compromising objectives.
- Time-bound so that the criteria can be monitored over an appropriate time frame to ensure the results are robust for ultimate relinquishment.

4.3.2 Development of completion criteria

In developing completion criteria for the Sandy Ridge Project, specific importance was placed on the EPA and DMP’s objectives for mine closure:

'rehabilitated mines to be (physically) safe to humans and animals, (geo-technically) stable, (geo–chemically) non-polluting / non-contaminating, and capable of sustaining an agreed post–mining land use'

Specific targets (i.e. completion criteria) are developed for three reasons:

- To allow effective reporting and auditing during the life of the Facility.
- On achievement, they represent an endpoint for closure activities where the site can be considered by internal and external stakeholders as 'rehabilitated[1]'.

The indicative completion criteria for the Sandy Ridge Project are presented in Table 4–1.

Table 4-1 Indicative completion criteria

Objective	Indicative Completion Criteria	Measurement Tool
Structurally stable, non–eroding disposal cells.	No subsidence of pits over the subsidence monitoring period.	Subsidence monitoring results provided in the Annual Environmental Report.
No emissions or discharges from the cells following capping.	No significant erosion of the cell caps. No radiation (gamma and radon) emissions greater than the acceptable public health levels. No adverse effects on groundwater.	Results of erosion, radiation, and groundwater monitoring will be provided in the Annual Environmental Report.
Establish vegetation on the cell caps.	At the completion of revegetation monitoring period vegetation composition is comparable to the species diversity/richness and structure of the analogue site. All plants used in rehabilitation to be of local provenance. No declared pests[2] to be introduced into the area.	Results of vegetation monitoring will be provided in the Annual Environmental Report.

[1] Defined in the MCP guidelines (DMP & EPA, 2015) as 'the return of disturbed land to a safe, stable, non–polluting / non–contaminating landform in an ecologically sustainable manner that is productive and self–sustaining consistent with the agreed post–mining land use'.

[2] Declared pests are defined under the *Biosecurity and Agriculture Management Act 2007* and have the meaning (a) a prohibited organism; or
(b) an organism for which a declaration under section 22(2) is in force.

5 TECHNICAL STUDIES

The Sandy Ridge Project is currently in the conceptual stage of planning therefore baseline data collected has been specifically to inform the environmental impact assessment. A summary of the reports completed to date and the data available is provided in Table 5–1.

Table 5-1 Baseline data collected to date

Aspect	Report Title and Author	Data available
Climate and weather observations	A weather station has been installed at the site and is operational. Daily and monthly data summaries are available to download from: www.weathermation.net.au.	Weather observation data on: Wind speed (maximum and average). Average wind direction. Maximum peak wind gust. Relative humidity (maximum, minimum and average). Air temperature (maximum, minimum and average). Rainfall (total and maximum). Data collected from 8 May 2015 to present on a daily basis.
Flora and Vegetation	Sandy Ridge Project, Exploration Tenement E16/440 Level 1 Flora and Vegetation Survey (PGV Environmental 2015)	Level 1 Flora and Vegetation Survey (desktop review).
	Sandy Ridge Project, Exploration Tenement E16/440 Flora and Vegetation Survey (PGV Environmental, 2016)	Level 2 Flora and Vegetation Survey (desktop review and field survey). Sampling of 25 non–permanent 20m by 20m quadrats and several traverses through proposed road and water pipeline alignments.
Fauna	Level 1 Fauna Survey (Terrestrial Ecosystems, 2015)	Level 1 Fauna Study (desktop review and reconnaissance survey).
	Targeted Malleefowl Survey (BCE, 2016)	Historical malleefowl mound locations.
Soils	Sandy Ridge Project Soil Assessment (Landloch, 2015a)	Characterisation of soil types. Soil chemical and physical analysis results. Available topsoil and subsoil resource.

Aspect	Report Title and Author	Data available
		Soil management techniques.
Hydrogeology	Hydrogeological Studies for the Sandy Ridge Project Drilling, Permeability Testing and Potential Water Sources Report (Rockwater, 2015)	Desktop review of previous hydrogeological investigations. Drilling and Monitoring Bore Construction methodology. Monitoring bore permeability tests. Description of hydrogeology. Water Supply Assessment.
Hydrology	Sandy Ridge Kaolinite Project Surface Water Assessment and Management Plan (Rockwater, 2016a) Sandy Ridge Kaolinite Project Surface Water Assessment and Management Plan: Addendum (Rockwater, 2016b)	Surface Catchment Hydrology. Surface Catchment Runoff Hydraulics. Water Management Requirements.
Geotechnical Assessment of Cell Design	Report on Geotechnical Assessment Sandy Ridge Project Goldfields, WA (Douglas Partners, 2015)	Permeability of Compacted Iron Stained Kaolinised Granite and Kaolin Stream Waste. Compaction of Backfilling Materials and Backfilling Methodology. Capping Layer Compaction and Methodology.
Aboriginal Heritage	Report on an Aboriginal Heritage Survey of Tellus Sandy Ridge Project (John Cecchi Heritage Management Consultancy, 2015)	Ethnographic background. Archaeological background. Survey methodology and results.
Characterisation of the clay capping material	Characterisation of the clay capping material from the Sandy Ridge Mine Site (Landloch, 2015b)	Chemical and physical analysis of kaolin capping material.
Landform Evolution Modelling	Sandy Ridge Landform Evolution Modelling (Landloch, 2016)	Erosion potential of the materials used for capping and evolution of the landform over 10,000 years.

5.1 Climate and weather observations

The Proposal falls within the bioclimatic category defined in Beard (1990) as 'semi desert Mediterranean' and averages approximately 250 mm of rainfall per annum. The proposed development envelope lies just to the south of one of the driest regions in Western Australia and does not receive enough rainfall to allow the regular production of crops. The closest Bureau of Meteorology weather station to the proposed development envelope is located at Menzies, approximately 110 km to the northeast. Table 5–2 summarises the Bureau of Meteorology's data for Menzies from around the last 100 years (BoM, 2015).

Table 5-2 Menzies climate data

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean Maximum Temperature													
Mean maximum temperature (°C)	35.1	33.9	31.1	26.2	21.3	17.7	17	19	23.1	26.8	30.7	33.9	26.3
Highest maximum temperature (°C)	46.2	45.6	45	39.4	33.9	28.3	28.3	31.1	36.4	40.8	42.9	45.2	46.2
Lowest maximum temperature (°C)	16.8	17.8	14.9	12.8	10.9	9.4	7.2	9.4	10.2	11.8	15.1	15	7.2
Minimum Temperature													
Mean minimum tempera	19.7	19.4	17.2	13.4	9.3	6.7	5.3	6.1	8.6	11.7	15.5	18.2	12.6

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
ture (°C)													
Highest minimum temperature (°C)	31	28.9	30.3	24	20.2	18.9	14.5	17.9	23.3	25	27.2	29.4	31
Lowest minimum temperature (°C)	11.7	10	7.6	1.1	-1.4	-4.8	-4	-3	-0.6	0.6	3.4	6.8	-4.8
Rainfall													
Mean rainfall (mm)	22.3	32.1	26.3	21.5	25.7	27.7	22.7	19.6	10.5	11.3	14.8	15.5	250

Source: BoM (2015a)

An Automated Weather Station (AWS) was setup within the proposed development envelope in May 2015. It has been recording hourly average data on; wind speed and direction, total rainfall, relative humidity and air temperatures since 8 May 2015. Table 5–3summarises the data collected to date (March 2016).

Table 5-3 Sandy Ridge weather station data

Data	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Annual
Maximum Temperature													

Data	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Annual
Mean maximum temperature (°C)	20.7	20.2	18.7	19.8	31.2	31.6	32.4	34.1	34.1	33.0	30.0		
Highest maximum temperature (°C)	24	25.5	22.8	28.7	32.7	39.2	40.8	41.6	41.9	42.8	39.5		
Lowest maximum temperature (°C)	16	13.2	13.8	9.6	15.9	21.2	22.2	25.8	25.9	23.6	18.0		
Minimum Temperature													
Mean minimum temperature (°C)	4.1	4.6	3.1	5.3	5.8	12.1	14.5	15.3	18.4	15.8	16.4		
Highest minimum temperature (°C)	12	11.8	11.9	13.7	14.7	20.4	20.0	21.0	24.4	23.7	23.2		
Lowest minimum temperature (°C)	0	0	0	0.03	0.03	4.2	4.5	5.46	12.1	9.5	8.1		
Rainfall													
Total rainfall (mm)	0.6	21.8	23.2	31.2	0	3.6	22.2	26.4	70.8	35	35.2		

5.2 Flora and vegetation

Key findings:

50 Threatened and Priority species located within 20 km radius of the mining lease.

Desktop review indicated 25 Priority species possible occur in the mining lease. None of these species are listed as Threatened under the EPBC Act or WC Act.

- 97 species from 27 Families and 50 Genera were recorded. The most common Families were the Myrtaceae (21 species), Fabaceae (13 species), Proteaceae (8 species) and Asteraceae (8 species). The Genera with the most species were Acacia (11), Eucalyptus (8), Grevillea (7) and Melaleuca (5).

- No introduced species (declared pests under the *Biosecurity and Agricultural Management Act 2007*) were recorded.
- No Threatened (Declared Rare) species listed under the *Wildlife Conservation Act 1950* (WC Act 1950) or *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act 1999) were recorded.
- One Priority 3 species, *Calytrix creswellii*, was recorded at one location in *Acacia resinimarginea* Open Heath on loamy sand in the middle of the pits/cells area. Numerous plants were recorded in the quadrat and nearby.
- One Priority 3 species, *Lepidosperma lyonsii*, was recorded on the proposed pipeline route between the Mount Dimer Road and the tenement. Several plants were recorded in *Eucalyptus pileata*/*Acacia resinimarginea* Shrub Mallee/Open Heath vegetation.
- Five populations of the undescribed sedge species, *Lepidosperma sp.*, were recorded in *Acacia resinimarginea* dominated vegetation on the site. The species is likely to be more widespread on the site than the populations recorded. The species was not able to be identified to specific level but was not considered to be any of the three Priority species previously recorded in the vicinity of the site. The taxonomy of Lepidosperma is being reviewed by the Western Australian Herbarium staff (R. Barrett) and until those results are published the Lepidosperma recorded on the site should be treated as potentially having some conservation value.
- Most of the vegetation in the survey area belongs to Beard vegetation association 437 ‘Shrublands; mixed acacia thicket on sandplain’ with the southwestern area belonging to association 141 ‘Medium woodland; York gum, salmon gum and gimlet’
- The vegetation condition was assessed as ‘Excellent’ using the Bush Forever condition scale.

5.3 Fauna

Key findings:

- Two fauna habitats were mapped within the mining lease and miscellaneous licence; open eucalypt woodland and shrublands.
- Most of the mining lease and miscellaneous licence is in Good to Very Good condition with the exception of vehicle tracks in the proposed pits/cells and infrastructure disturbance areas.
- Potential for 22 fauna species of conservation significance to occur within the mining lease and miscellaneous licence.
- Four of these species are listed as Threatened and two as Migratory under the EPBC Act. None of these species have previously been recorded within the mining lease and miscellaneous licence.

- No malleefowl or active mounds were observed during the targeted survey. Old mounds were evident, with 63 identified during the survey of various ages and in varying states of degradation. Most were little more than circular raised areas of gravel, potentially unused for decades or centuries.
- Two rainbow bee-eaters were observed during the survey; however as the nesting period had finished for the season it was assumed the birds were just passing through (M. Bamford, pers.comm).

5.4 Soils

Key findings:

- The field assessment identified two soil types; Deep Yellow Sand and Red Sandy Duplexes.
- The Deep Yellow Sand is associated with the higher relief areas of low sandy dune systems. The pH of the Deep Yellow Sand is strongly acidic.
- The Red Sandy Duplex is associated with the lower-lying areas of the exploration lease, potentially broad areas of through going drainage, and consequently are areas of net erosion. The Red Sandy Duplexes were found at shallow depths (<0.3m BGL) over a tightly packed laterite ferricrete. The pH of the Red Sandy Duplex was neutral at surface to alkaline at depth.
- A description of each soil type is listed in Table 5–4 and Table 5–5, and the physical and chemical laboratory test results are provided in Table 5–6.

Table 5-4 Characteristics of the red sandy duplexes

Property	Inspection Site Description
Brief description	Shallow dark red/brown sand over sandy clay loam
Soil samples	Pit 1, Pit 2
Gradients	Gently undulating
Soil Landscape	Norseman
Soil classification	Petroferric Kandosol
Surface coarse fragments	0-20% abundance sub-angular pebbles to small rocks
Surface condition	Soft to moderate
Permeability	Moderate (surface), slow (subsurface)
Water repellent	No
Drainage	Sheet wash and low relief drainage lines
Soil depth (cm)	**Soil Profile Description**
0-5	A_1 Dark red-brown (2.5YR-2.5/4), weakly structured, sand, <5% coarse pebble fragments, pH 7 (field)
5-20	A_2 Dark red-brown (2.5YR-3/6), weakly structured, loamy sand, <2% coarse pebble fragments, pH 7 (field)
20-30	A_2 Dark red-brown (10R-3/6), weakly structured, sandy clay loam, <2% coarse pebble fragments, pH 8 (field)
>30	Very hard pale laterite/ferricrete of unknown depth

Table 5-5 Characteristics of the deep yellow sands

Property	Inspection Site Description
Brief description	Deep yellow acidic sand
Soil samples	Pit 3, Pit 4
Gradients	Flat to gently undulating
Soil Landscape	Norseman
Soil classification	Yellow Orthic Tenosol
Surface coarse fragments	<2%
Surface condition	Soft
Permeability	Moderate to high
Water repellent	No
Drainage	Surface sheet
Soil depth (cm)	**Soil Profile Description**
0-5	A_1 yellow red (7.5YR-6/6), massive, sand, few coarse fragments, pH ~4.5 (field)
>15	B_2 Dark red (7.5YR-7/6), massive, loamy sand, few coarse fragments, pH ~4.5 (field)

Table 5-6 Chemical and physical soil test results

Analyses		Unit	Sample ID					
			Red Sandy Duplexes			*Deep Yellow Sands*		
			Pit 2-1	**Pit 2-2**	**Pit 2-3**	**Pit 4-1**	**Pit 4-2**	**Pit 4-3**
			5cm	**20cm**	**30cm**	**5cm**	**20cm**	**50cm**
$pH_{1:5}$		pH units	7	7.06	8.89	4.92	4.37	4.21
Electrical conductivity ($EC_{1:5}$)		dS/cm	0.02	0.02	0.17	0.03	0.02	0.02
Total nitrogen		mg/kg	205	104	249	232	206	470
Total phosphorus		mg/kg	<75	<75	<75	<75	<75	<75
Organic carbon		%	0.47	0.20	0.28	0.73	0.41	0.17
Plant Available Nutrients	Phosphorus - Colwell	mg/kg	13.8	5.4	5.1	5.9	3.6	3.5
	Potassium – Colwell	mg/kg	218	28.2	208	44.3	22.6	46.7
	Sulphur – KCl	mg/kg	4.1	3.8	8.3	8.5	11.8	26.0
	Copper – DTPA	mg/kg	0.34	Not detected	Not detected	0.32	Not detected	Not detected
	Iron – DTPA	mg/kg	7.3	Not detected	Not detected	25.1	Not detected	Not detected
	Manganese – DTPA	mg/kg	2.3	Not detected	Not detected	0.9	Not detected	Not detected
	Zinc - DTPA	mg/kg	0.2	Not detected	Not detected	0.2	Not detected	Not detected
Exchangeable Cations	Calcium	meq/100g	2.49	2.18	9.52	0.92	0.62	0.51
	Magnesium	meq/100g	0.46	0.71	3.38	0.25	0.15	0.13
	Potassium	meq/100g	0.33	0.36	1.75	0.31	0.34	0.26
	Sodium	meq/100g	0.14	0.10	1.2	0.14	0.13	0.09
	Aluminium	meq/100g	0.04	0.01	0.02	0.006	0.36	0.37
	Effective Cation	meq/100g	3.5	3.4	15.9	1.7	1.6	1.4

Analyses		Unit	Sample ID					
	Exchange Capacity							
	Exchangeable Sodium Percentage	%	4.1	2.9	7.6	8.4	7.9	6.4
Particle Size Distribution of Fine Fraction	Coarse Sand 0.2-2.0mm	%	70.4	67.3	49.2	70.3	68.9	57.7
	Fine sand 0.02-0.2mm	%	26.5	29.6	29.1	23.8	22.5	33.8
	Silt 0.002-0.02mm	%	0.4	0.4	0.4	2.2	0.4	2.2
	Clay <0.002mm	%	2.7	2.7	21.3	3.6	8.2	6.3
Dispersion Index		Class	3	3	2	7	6	6

5.5 Hydrogeology

Key findings:

- The Sandy Ridge Project is in an area underlain by granitic rocks where there is a thick weathering profile. Little or no groundwater has been intersected within the mining lease, in either the mineral exploration drilling or the 2015 investigation programme conducted by Rockwater. One mineral exploration hole intersected damp kaolinite within the planned mining area.
- Three holes located in areas of greater depth to fresh granite, in the west and south-western parts of the pits/cells area, intersected small quantities of moderately saline groundwater (6,000 to 7,000 mg/L TDS). Airlift water yields ranged from zero to about 0.03 L/s, and permeabilities of the water-bearing zones were low, showing they do not constitute an aquifer.
- The kaolinite and weathered granite are indicated to be of low to moderately low permeability (0.02 to 0.99 m per day, or 2.3×10^{-7} to 1.2×10^{-5} m per second). Permeability values for the dry holes should be taken as first estimates and are probably higher than actual values, because of limitations of the test method.
- The most practical source of water for the project appears to be the Carina iron ore mine, located 12 km south-west of Sandy Ridge in the Yendilberin Hills, where there is abundant water available from the pit and/or dewatering bores (up to 3,000 kL/d). The water has a salinity of about 33,000 mg/L TDS. It is highly unlikely that accessing water from Carina mine will have any additional impact at Carina because the volume sought is small and this water would in any case have been lost by evaporation and seepage. Also, the mine is remote (at least 10 km) from other groundwater users (except Mineral Resources).

5.6 Hydrology

Key findings:

- The planned mining area is unaffected by any major flow paths, and surface water management is only required for short–term flows during rare high rainfall events. These flows are generally from small local catchments which drain residual runoff after infiltration losses to low-lying depressions. Generally water will only be retained for very short periods in the depressions due to continuing infiltration loss. Water could pond for longer periods if the depressions are clay pans. Evaporation will contribute to the loss of ponded water.
- Based on the maximum recorded rainfalls in the area and typical infiltration rates for sandy and sandy loam soils, it is concluded that the peak flows estimated using the only Rational Method for the arid interior region of WA are grossly over-estimated. However, the Rational Method was used in the hydraulic analysis for conceptual design of flood management works.
- Site observations of actual flows following rainfall events should be collected as they will play an important role in refining the water management requirements in the detailed design stage.
- It is recommended that two levees L14a to L18a and L8a to L7a (Figure 2 of Rockwater 2015c) be constructed to divert peak flows around the mining and plant areas. The natural topography along these levees would require minimal grading.

5.7 Aboriginal heritage

Key finding:

- No sites of aboriginal heritage were identified during the survey.

5.8 Geotechnical assessment of cell design

Key findings:

- The results of the tests indicate a permeability of between 5.7 x 10^{-8} m per second and 6.4 x 10^{-8} m per second (approximately 5 mm per day to 5.5 mm per day) for the iron stained kaolinised granite and between 1.6 x 10-8 m per second and 3.0 x 10^{-8} m per second (approximately 1.4 mm per day to 2.5 mm per day) for the kaolinitic material rejected from the processing plant.
- Granular filling to be placed within 2% of optimum moisture and compacted to 90% of maximum modified dry density (MMDD).
- Compaction testing carried out using a nuclear density gauge in accordance with *AS 1289.5.8.1*.
- The capping layer should be compacted to an average of 98% standard maximum dry density (SMDD), and the minimum compaction should be 95% MMDD.

5.9 Characteristics of the clay capping material

Key findings:

- Kaolin is relatively benign in terms of its chemical characteristics. Some samples were slightly acidic and saline, but most trended towards neutral to non–saline.
- All metals analysis were below ecological investigation levels (DEC, 2010) and this suggests there is no pre–existing contamination present in the samples analysed.
- The material is fine textured, has low permeability (0.26 – 1.2 mm/hr), and may potentially be hardsetting, indicating it may potentially erode.
- The physical and chemical characteristics of the clay capping material is listed in Table 5–7.

Table 5-7 Clay capping physical and chemical characteristics

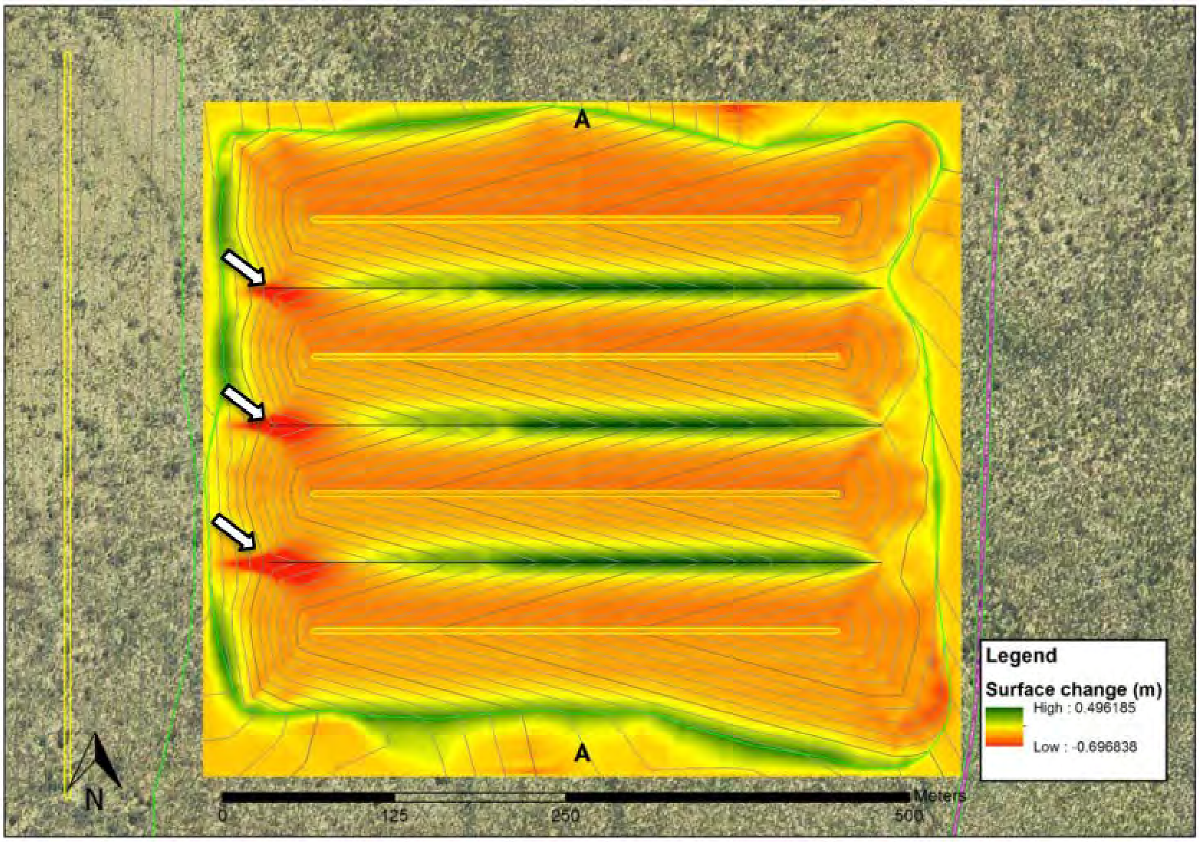
Property		Unit	TC1	TC2	TC3	TC4	TC5	TC6
pH		pH units	6.72	6.91	6.59	6.51	5.75	6.59
Electrical conductivity		dS/cm	0.48	0.40	0.74	1.17	0.19	0.60
Exchangeable Cations	Calcium	meq/100g	0.69	0.74	0.72	0.55	0.49	0.71
	Magnesium	meq/100g	1.43	1.64	1.29	0.77	1.28	1.03
	Potassium	meq/100g	0.23	0.30	0.14	0.08	0.11	0.08
	Sodium	meq/100g	0.50	1.39	0.31	0.13	0.91	0.13
	Aluminium	meq/100g	0.01	0.01	0.01	0.01	0.01	0.01
	Effective Cation Exchange Capacity	meq/100g	2.8	4.1	2.5	1.5	2.8	2.0
	Exchangeable Sodium Percentage	%	17.4	34.1	12.5	8.4	32.4	6.49
Particle Size Distribution of Fine Fraction	Coarse Sand 0.2-2.0mm	%	50.3	33.2	49.1	39.0	46.3	39.4
	Fine sand 0.02-0.2mm	%	32.6	37.4	22.3	38.3	24.9	38.8
	Silt 0.002-0.02mm	%	13.8	28.1	10.8	16.4	14.5	18.4
	Clay <0.002mm	%	3.2	1.3	17.7	6.3	14.3	3.4
Plant Available Water		%	14	18	7	12	10	16
Dispersion Index		Class	6	6	6	6	6	6
Saturated Hydraulic Conductivity		mm/hr	0.46	0.26	1.20	0.29	0.50	0.45
Arsenic		mg/kg	<5	<5	<5	<5	<5	<5
Barium		mg/kg	<10	<10	<10	<10	<10	<10
Beryllium		mg/kg	<1	<1	<1	<1	<1	<1
Boron		mg/kg	<50	<50	<50	<50	<50	<50
Cadmium		mg/kg	<1	<1	<1	<1	<1	<1
Chromium		mg/kg	7	4	3	5	<2	<2
Cobalt		mg/kg	<2	<2	<2	<2	<2	<2
Copper		mg/kg	<5	<5	<5	<5	<5	<5
Lead		mg/kg	<5	<5	<5	<5	<5	<5
Manganese		mg/kg	<5	<5	<5	<5	<5	<5
Nickel		mg/kg	3	2	<2	2	<2	<2
Selenium		mg/kg	<5	<5	<5	<5	<5	<5
Vanadium		mg/kg	<5	10	<5	<5	<5	<5
Zinc		mg/kg	<5	<5	8	20	<5	7
Mercury		mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

5.10 Landform evolution modelling

Key findings:

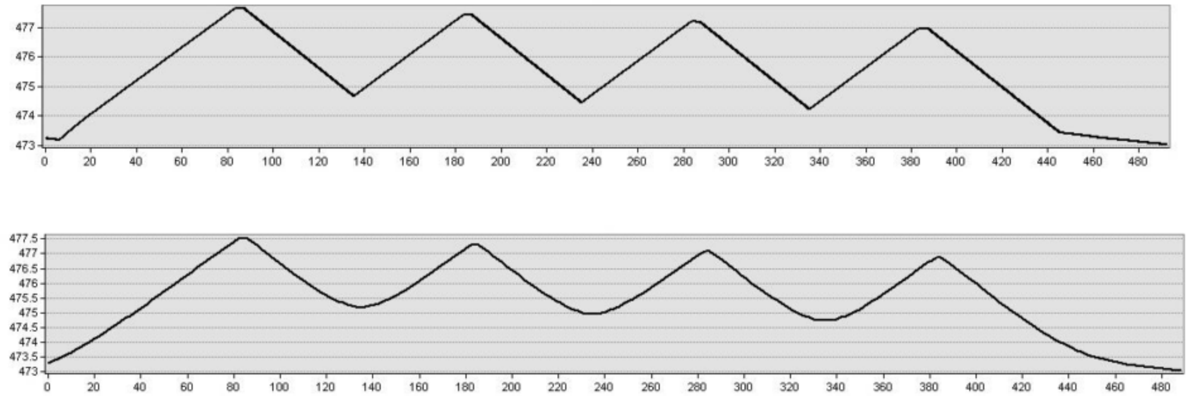
- The Facility design of 5 m high cells (i.e. landforms) with 3 degree batters covered with a deep layer of topsoil is predicted to be erosionally stable over the very long term. This is due to the permeability of the topsoil, arid climate, and a gently sloping design.
- There is predicted to be relatively little change to the Facility surface over the simulation period (10,000 years). Typically less than 200 mm is eroded from the cell batter slopes and deposited in between cells with a maximum of 500 mm deposition predicted (Figure 5–1).

Figure 5–1 SIBERIA model 10,000 year results for long term landscape evolution of cells



The predicted original surface and the surface after 10,000 year simulation is shown in Figure 5–2.

Figure 5–2 SIBERIA model results cross section for the original surface (top) and at 10,000 years (bottom). Axis in meters.



6 RISKS IDENTIFIED FOR CELL CLOSURE

A risk assessment has been undertaken for all aspects of the Facility closure, in accordance with the procedures outlined in the Australian and New Zealand Standards *AS/NZS ISO 31000:2009* Risk *Management–Principles and Guidelines* (SAI Global, 2009) and *HB 203:2012 (Managing Environment-Related Risk)(* SAI Global, 2012), using Tellus' Risk Assessment Matrix (Appendix A.3).

The sources of risks, environmental aspects and potential environmental impacts, as defined by *HB 203:2012* were identified in a workshop attended by the Sandy Ridge Project Leader and Aurora Environmental representatives. The identified environmental aspects were categorised into 'planned' that is those aspects which Tellus know will occur during closure, and those that are 'unplanned' and may credibly occur during closure, but which Tellus has no control over the frequency of occurrence. The identified potential environmental impact is based on the 'worst–case' credible impact.

Qualitative risk analysis was then undertaken, based on the likelihood of the potential environmental impact occurring. Analysis of the inherent risk was undertaken assuming no management/mitigation controls were in place. The group then discussed appropriate management and mitigation measures that would be implemented to reduce the likelihood or consequence, and then analysed the final residual risk.

The outcome of the risk assessment included the identification of 6 planned and 9 unplanned credible risks. This included:

- 3 – High residual risks.
- 1 – Moderate residual risks.
- 11 – Low residual risks.

The risks relating specifically to closure of the Facility are summarised in Table 6–1, with the full risk assessment (including other risks presented in the Mine Closure Plan) presented in Appendix A.3.

The high and moderate risks were evaluated following the workshop by the Sandy Ridge Project Leader, whom concluded that the occurrence of high and moderate risks were outside of Tellus' control due to them being naturally occurring events, or people entering the site without permission. For these risks no treatment was considered necessary, other than maintaining the proposed controls.

Table 6-1 Closure risk register

Environmental Aspect	Sources of Risk (Hazard)	Potential Environmental Impact (Worst case)	Pre-treatment risk	Management and Mitigation Measures	Post-treatment Risk		Residual risk
					Likelihood	Consequence	
Naturally occurring events.	Earthquake (major - with surface displacement)	Cracking of cap, water infiltration and contamination plume.	High	Multiple layer cap design; thickness and self-sealing ability of kaolinite in capping layers; near surface geology and climatic conditions result in net upward water movement in top 6m. Front end loader to fix immediately.	Rare	Major	High
Naturally occurring events.	Bushfire during institutional control period	Injury or death of Threatened/Priority fauna. Damage or death of revegetation.	High	Drying climate, low fuel load.	Almost certain	Insignificant	High
Terrorist attack	Plane crash, bombing of the cells.	Expulsion of chemical and radioactive waste from the cell to the surface and into the atmosphere.	High	Movement detectors positioned at the waste cells, remoteness of the location, depth of cover (i.e. 7m of capping layers before waste package layer), low incentive, and consequence to effort scale poor.	Rare	Major	High
Unauthorised access to the site	Unrestricted public access (e.g. holes in fencing) and	Injury or death of individual fauna by falling into cell containing	Moderate	Perimeter fence. Institutional control on exploration activities (i.e.	Rare	Moderate	Moderate

Environmental Aspect	Sources of Risk (Hazard)	Potential Environmental Impact (Worst case)	Pre-treatment risk	Management and Mitigation Measures	Post-treatment Risk		Residual risk
					Likelihood	Consequence	
	accidental deep excavation/drilling into the cell. Mineral exploration.	chemical waste, cell becomes unstable and collapses inwards.		government can prevent exploration).			
Direct rainfall events	Low saturated hydraulic conductivity (0.26 - 1.2mm/hr) of kaolin will result in high rainfall runoff, causing erosion.	Erosion of the domed clay cap, water infiltration into the cell, plume of contamination release which could affect flora and vegetation.	Low	Place topsoil/subsoil (minimum 1.7m thick) over clay cap. Infiltration rate low. Front end loader to fix cap. Deeper cap lower in waste cell. Clay is dry and will absorb any water. Bunding and V drains around cell cap.	Rare	Insignificant	Low
Surface water runoff	Low saturated hydraulic conductivity (0.26 - 1.2mm/hr) of kaolin will result in high rainfall runoff, causing erosion.	Erosion of the domed clay cap, water infiltration into the cell, plume of contamination release which could affect flora and vegetation.	Low	Place topsoil/subsoil (minimum 1.7m thick) over clay cap. Infiltration rate low. Front end loader to fix cap. Deeper cap lower in waste cell. Clay is dry and will absorb any water. Bunding and V drains around cell cap.	Rare	Insignificant	Low
Decommissioning of the site	Movement of plant and collision with fauna.	Injury or death of Threatened/Priority fauna.	Low	Speed limit <20km/hr.	Rare	Insignificant	Low

Environmental Aspect	Sources of Risk (Hazard)	Potential Environmental Impact (Worst case)	Pre-treatment risk	Management and Mitigation Measures	Post-treatment Risk		Residual risk
					Likelihood	Consequence	
Decommissioning of the site	Overturned truck/removal of tanks, forget to drain hydrocarbon lines.	Hydrocarbon spill and soil contamination.	Low	Front end loader onsite, cleanup procedures, extent is limited by absorptive nature of the clay, presence of silcrete layer. Adequate planning of demolition. Education of contractors.	Unlikely	Insignificant	Low
Fencing of the waste cells	Exclusion of fauna from potential habitat.	Forced translocation of fauna into other habitat and increased predation in new habitat. Potential for injury/death of Threatened/Priority fauna.	Low	Removal of fencing following Post Closure Management Period.	Rare	Insignificant	Low
Monitoring of the site	People accessing the site to complete monitoring.	Accidental fire (e.g. cigarette butt) leading to loss of vegetation.	Low	Education of contractors on fire prevention methods, vegetation is sparse and unlikely to be high fuel load.	Rare	Minor	Low
Vegetation growing on domed clay cap.	Plant roots, permeability pathways created.	Potential penetration of roots into cap, water infiltration	Low	Thickness of all capping layers. Kaolin is a poor growth medium,	Rare	Insignificant	Low

Environmental Aspect	Sources of Risk (Hazard)	Potential Environmental Impact (Worst case)	Pre-treatment risk	Management and Mitigation Measures	Post-treatment Risk		Residual risk
					Likelihood	Consequence	
		into the cell, plume of contamination release which could affect flora and vegetation.		regular monitoring and removal of vegetation that does grow.			
Failure of waste cell containment, cell instability/collapse.	Loss of volume or void space occurs. Backfill not completed correctly. Waste package contains liquid/gas. Generation of leachate as water infiltrates the cell.	Infiltration of liquid to surrounding clay and ultimately into groundwater, contaminating the water. Toxic plume within the aquifer affecting groundwater dependent vegetation, potentially Threatened/Priority flora and fauna species.	Low	Subsidence monitoring, groundwater monitoring bores around cells.	Rare	Insignificant	Low
Decommissioning of the site	Footprint of removed infrastructure not rehabilitated	Generation of dust (potentially contaminated) which affects sensitive receptors.	Low	Contribution to Mining Rehabilitation Fund (refer to MCP) and Tellus insurances.	Rare	Insignificant	Low
Naturally occurring events.	Earthquake (minor - no surface displacement)	Slight subsidence of cell	Low	Multiple layer cap design; thickness and self-sealing ability of kaolinite in capping	Rare	Insignificant	Low

Environmental Aspect	Sources of Risk (Hazard)	Potential Environmental Impact (Worst case)	Pre-treatment risk	Management and Mitigation Measures	Post-treatment Risk		Residual risk
					Likelihood	Consequence	
				layers; near surface geology and climatic conditions result in net upward water movement in top 6m.			
Introduction of weeds	Incoming vehicles to monitor the site.	Establishment of weeds on the site and competition for resources (e.g. water) with native vegetation.	Low	Inspection/brushdown of exterior of car before entering site. Brushdown of car between revegetation areas. Weed removal where they become established.	Rare	Insignificant	Low

7 OPERATIONS PHASE

7.1 Status Year 0 to 25

The operations phase is the period where active cells are:

- backfilled and capped as outlined in Section 7.2 (chemical waste cells) and 7.3 (chemical and radioactive waste cells).
- validated, in terms of the cell design as outlined in Section 7.4.
- monitored for subsidence as described in Section 7.5.
- overlayed with soil as described in Section 7.7.
- vegetated as described in Section 7.8.

In addition the following activities occur at the Facility:

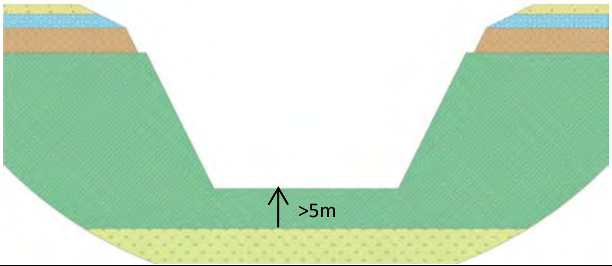
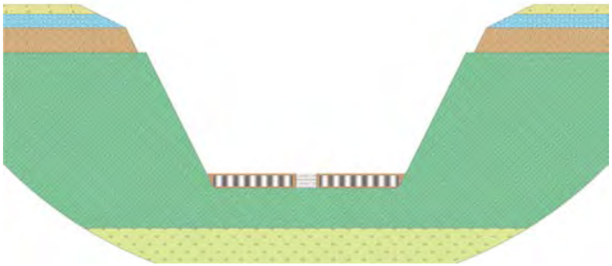
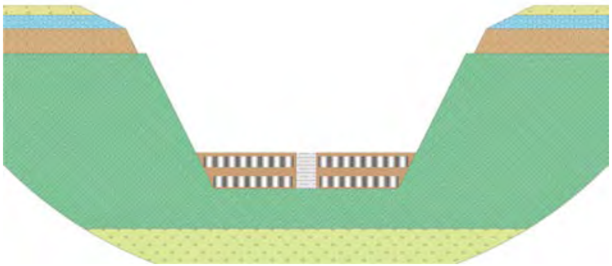
- radiation monitoring is conducted as described in Section 7.9.
- groundwater monitoring is conducted as described in Section 7.10.
- fencing around the cells is maintained as described in Section 7.11.

The cells will be rehabilitated in accordance with the schedule provided in Section 7.5. The rehabilitation schedule for the underground storage area is provided in Section 7.12.

7.2 Backfill and capping of chemical waste cells

The typical closure process for each chemical waste cell is outlined in Table 7–1 below. Note that a roof canopy will be in place until the waste packages are completely capped by kaolin clay.

Table 7-1 Closure of chemical waste cells

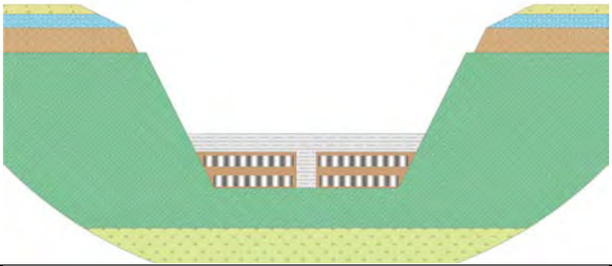
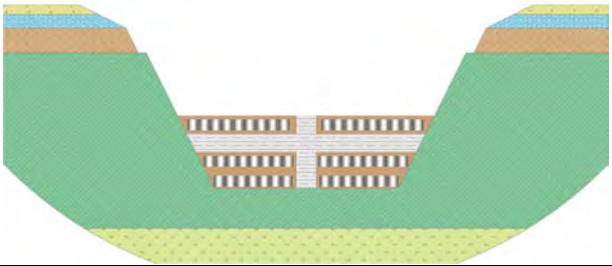
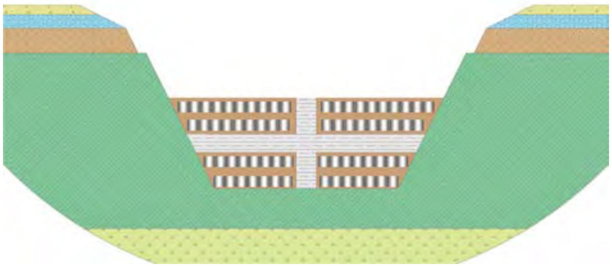
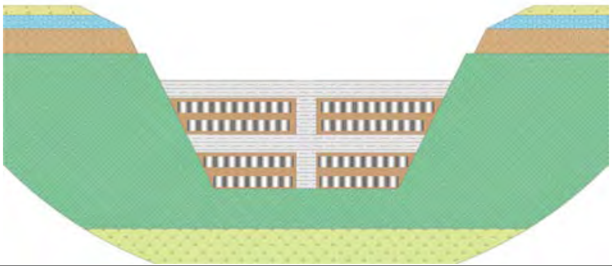
The bottom of the mine void will be a minimum of 5 m above the unweathered granite bedrock.	
A base layer of waste is placed on the floor of the mine void. Wastes of different types are segregated by internal compacted kaolin walls which are 5 m wide. The height of each waste layer and barrier wall is the equivalent of the height of a waste package, typically 0.9 m. Waste packages are placed tightly next to each other in a row. Granular material is backfilled between and around the waste packages to fill any air spaces.	
A thin (300 mm minimum) layer of compacted granular material is placed over the waste layer. Compaction testing will be carried out in accordance with *AS1289.5.8.1* to confirm material is compacted to the density required by the engineering design. The next layer of chemical waste packages is placed on the kaolin compacted layer along with the 5 m wide kaolin separation barrier.	

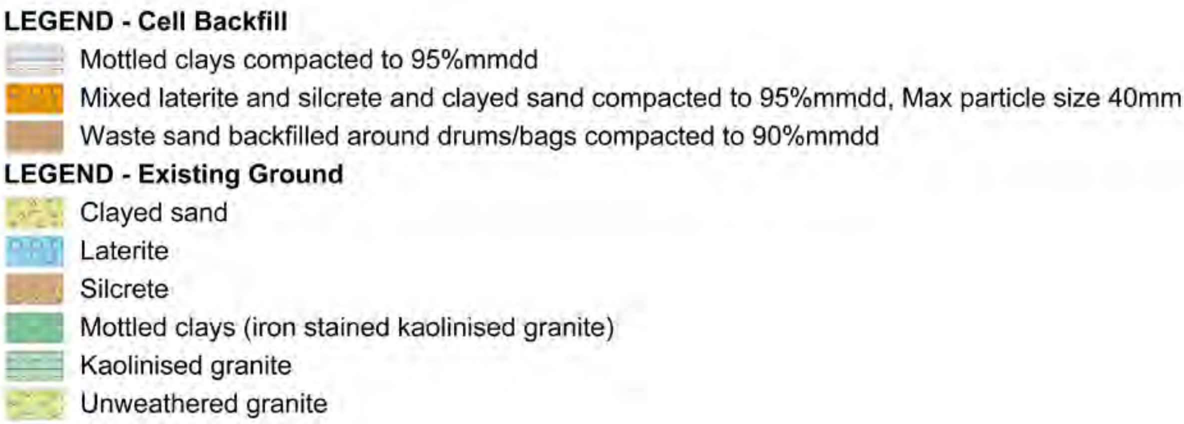
LEGEND - Cell Backfill

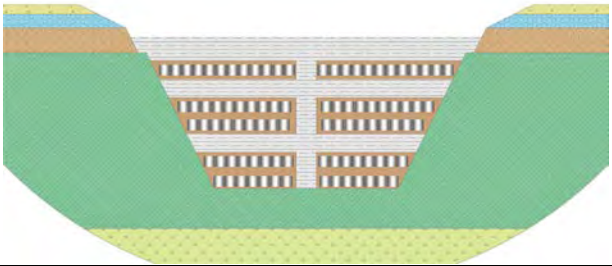
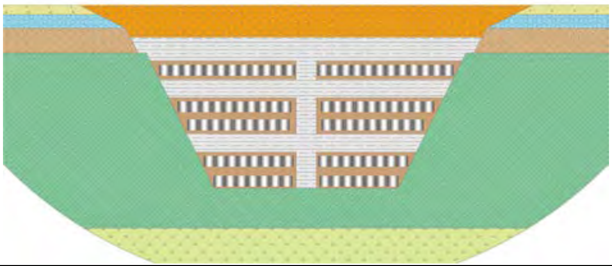
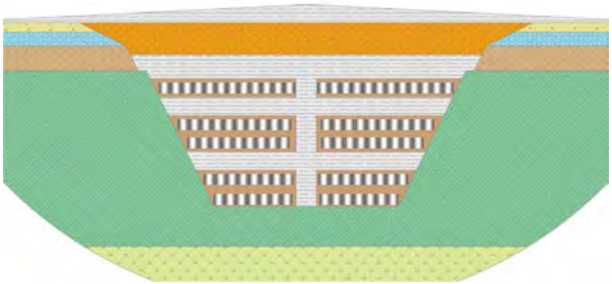
- Mottled clays compacted to 95%mmdd
- Mixed laterite and silcrete and clayed sand compacted to 95%mmdd, Max particle size 40mm
- Waste sand backfilled around drums/bags compacted to 90%mmdd

LEGEND - Existing Ground

- Clayed sand
- Laterite
- Silcrete
- Mottled clays (iron stained kaolinised granite)
- Kaolinised granite
- Unweathered granite

A 3 m thick capping layer of kaolin is compacted onto the second waste layer.	
The next layer of waste packages is tightly placed on the thick capping layer and backfilled with granular material to exclude air pockets and voids. The separation barrier is maintained in the middle of the cell.	
A thin (300 mm minimum) layer of compacted granular material is placed over the waste layer. Compaction testing will be carried out in accordance with *AS1289.5.8.1* to confirm material is compacted to the density required by the engineering design. The next layer of chemical waste packages is placed on the kaolin compacted layer along with the 5 m wide kaolin separation barrier.	
A 3 m thick capping layer of kaolin is compacted onto the fourth waste layer.	



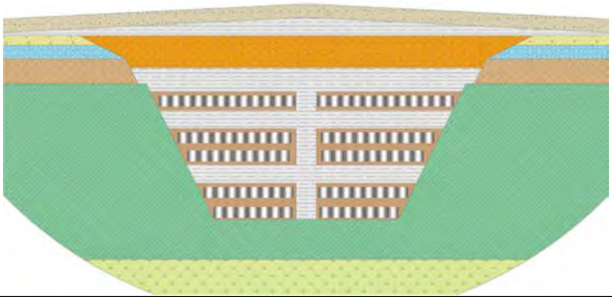
A fifth layer of waste is placed in the cell. A 3 m thick kaolin cap is placed on the waste packages and keyed into the surrounding clay.	
A 4 m thick layer of compacted crushed silcrete and laterite material, with some kaolinised granite or clayey sand is placed between the kaolin cap and the natural ground surface.	
Compacted kaolin clay dome cap is placed over the cell. The final capping layer is formed of compacted kaolinised granite material (permeability approximately 6.0 x 10^{-8} m/s (Douglas Partners, 2015)) and placed in the form of a dome, so as to shed stormwater from the structure into perimeter V drains, which flow to a sump. The cap will have a 1:20 gradient and be an approximately thickness of 2 m in the middle, thinning as it slopes to integrate into the landscape. Subsidence monitoring of the cap will commence.	

LEGEND - Cell Backfill

- Mottled clays compacted to 95%mmdd
- Mixed laterite and silcrete and clayed sand compacted to 95%mmdd, Max particle size 40mm
- Waste sand backfilled around drums/bags compacted to 90%mmdd

LEGEND - Existing Ground

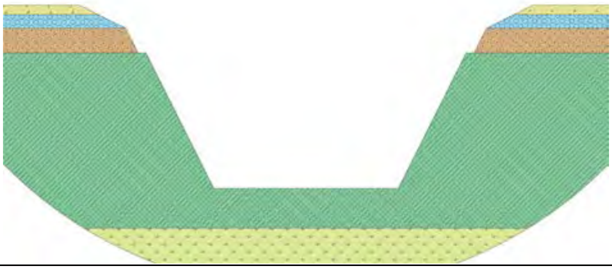
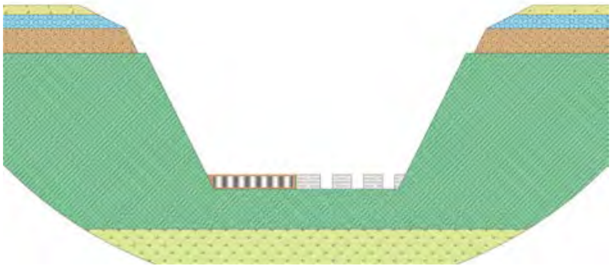
- Clayed sand
- Laterite
- Silcrete
- Mottled clays (iron stained kaolinised granite)
- Kaolinised granite
- Unweathered granite

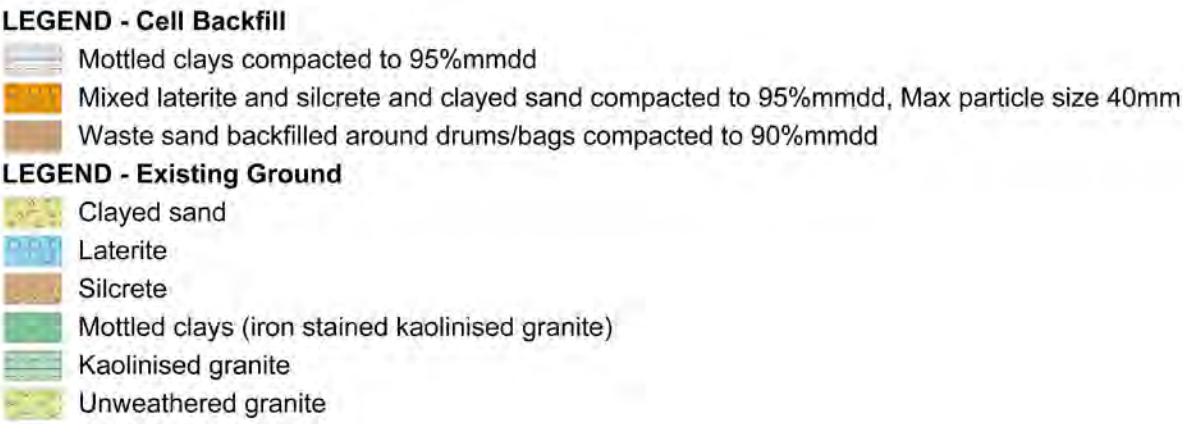
Subsoil and topsoil is replaced on the cap after the cessation of subsidence monitoring. This layer will be a minimum of 1.7 m thick.	

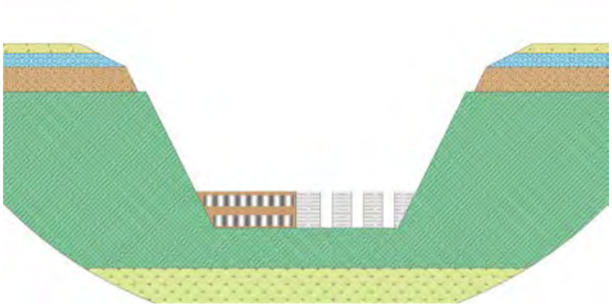
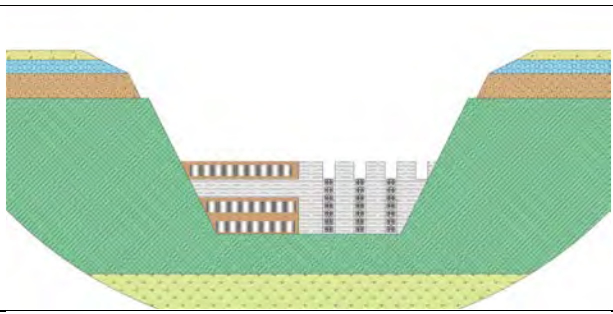
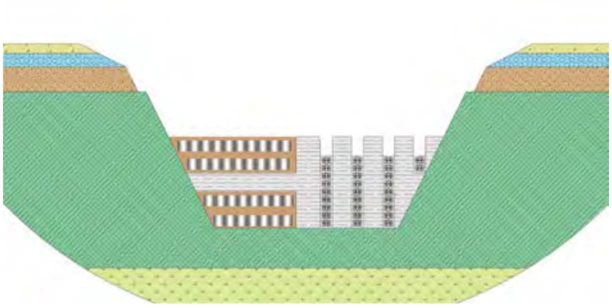
7.3 Closure of co–disposed chemical and radioactive waste cells

The closure process for each cell is outlined in Table 7–2 below.

Table 7-2 Closure of chemical waste and radioactive waste cells

The bottom of the mine void will be a minimum of 5 m above the unweathered granite bedrock.	
A base layer of waste is placed on one side the floor of the mine void. Wastes of different types are segregated by internal compacted kaolin walls which are 5 m wide. The height of each waste layer and barrier wall is the equivalent of the height of a waste package, typically 0.9 m. Waste packages are placed tightly next to each other in a row. Granular material is backfilled between and around the waste packages to fill any air spaces. The shafts for radioactive waste are constructed approximately 3 m apart from	



each other and with a 5 m barrier between the shafts and the chemical waste layer.	
A thin (300 mm minimum) layer of compacted granular material is placed over the chemical waste layer. Compaction testing will be carried out in accordance with *AS1289.5.8.1* to confirm material is compacted to the density required by the engineering design. The next layer of chemical waste packages is placed on the kaolin compacted layer along with the 5 m wide kaolin separation barrier. The shafts for radioactive waste continue to be constructed.	
A 3 m thick capping layer of kaolin is compacted onto the second waste layer. The shafts for radioactive waste continue to be constructed.	
The next layer of waste packages is tightly placed on the thick capping layer and backfilled with granular material to exclude air pockets and voids. The separation barrier is maintained in the middle of the cell. The radioactive waste is lowered into the shafts. Between each radioactive waste package a 200 mm layer of kaolin is compacted into place.	

LEGEND - Cell Backfill

Mottled clays compacted to 95%mmdd

Mixed laterite and silcrete and clayed sand compacted to 95%mmdd, Max particle size 40mm

Waste sand backfilled around drums/bags compacted to 90%mmdd

LEGEND - Existing Ground

Clayed sand

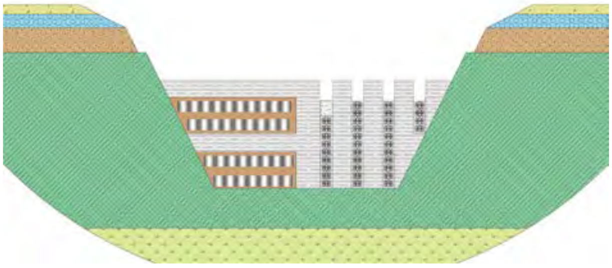
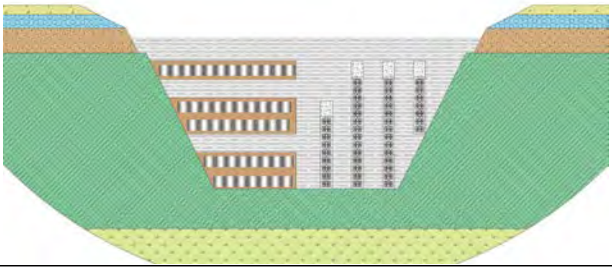
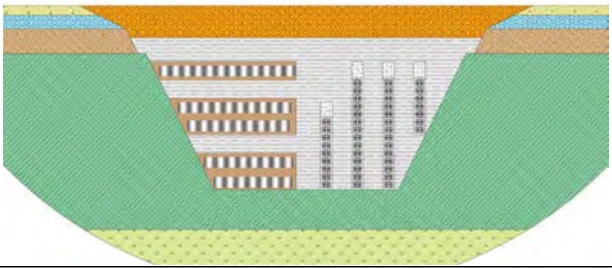
Laterite

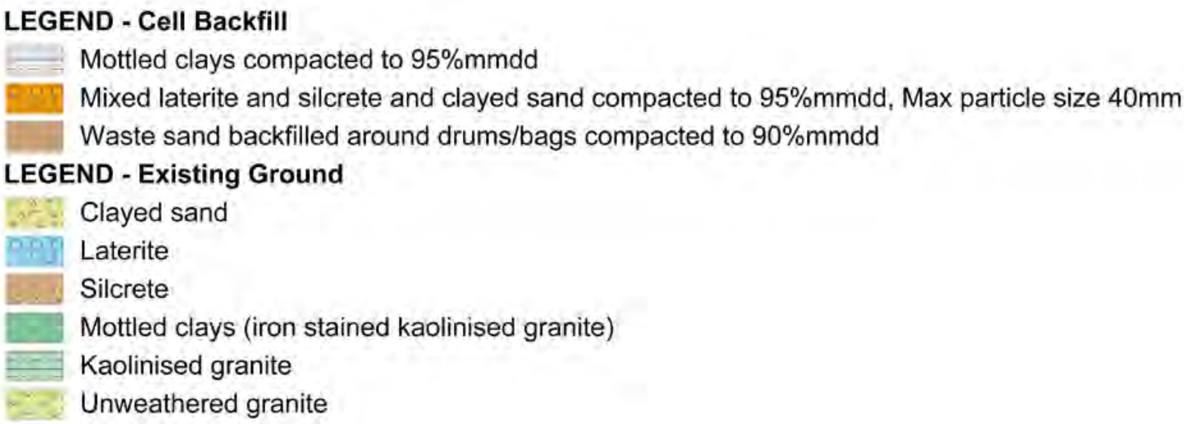
Silcrete

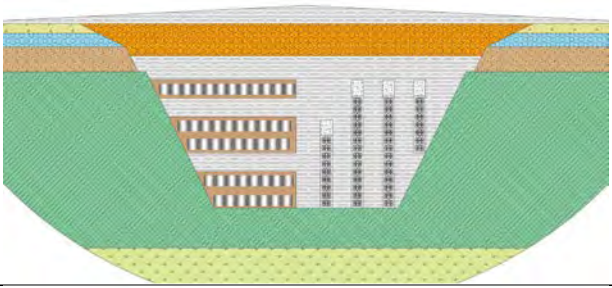
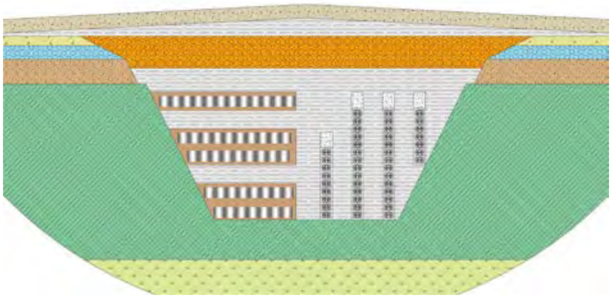
Mottled clays (iron stained kaolinised granite)

Kaolinised granite

Unweathered granite

A thin (300 mm minimum) layer of compacted granular material is placed over the chemical waste layer. Compaction testing will be carried out in accordance with *AS1289.5.8.1* to confirm material is compacted to the density required by the engineering design. The next layer of chemical waste packages is placed on the kaolin compacted layer along with the 5 m wide kaolin separation barrier. Radioactive waste continues to be lowered into the shafts. Between each radioactive waste package a 200 mm layer of kaolin is compacted into place.	
A 3 m thick capping layer of kaolin is compacted onto the fourth waste layer. Radioactive waste continues to be lowered into the shafts. Between each radioactive waste package a 200 mm layer of kaolin is compacted into place.	
A fifth layer of waste is placed in the cell. Concrete lids are fitted into each radioactive shaft. A 3 m thick kaolin cap is placed on the waste packages and concrete lids and is keyed into the surrounding clay.	

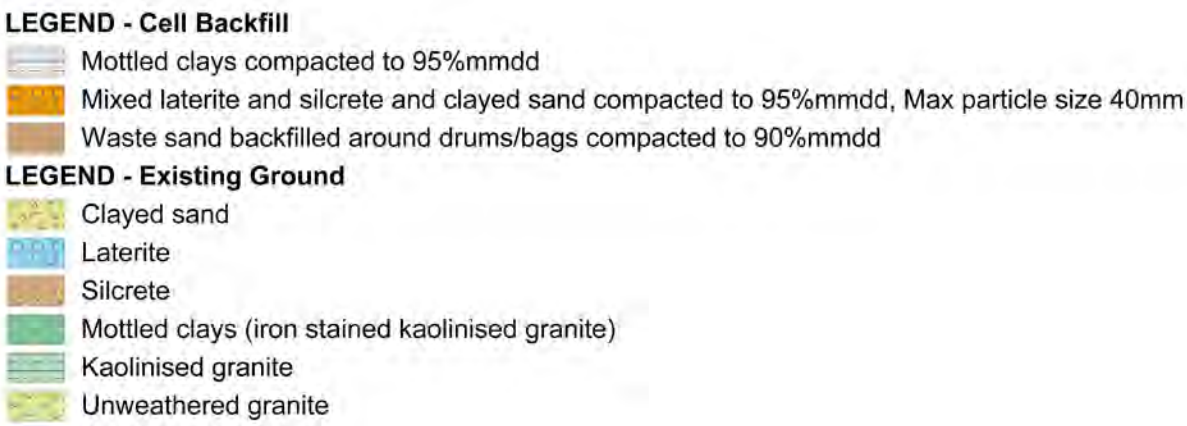


A 4 m thick layer of compacted crushed silcrete and laterite material, with some kaolinised granite or clayey sand is placed between the kaolin cap and the natural ground surface.	
Compacted kaolin clay dome cap is placed over the cell. The final capping layer is formed of compacted kaolinised granite material (permeability approximately 6.0 x 10^{-8} m/s (Douglas Partners, 2015)) and placed in the form of a dome, so as to shed stormwater from the structure into perimeter V drains, which flow to a sump. The cap will have a 1:20 gradient and be an approximately thickness of 2 m in the middle, thinning as it slopes to integrate into the landscape. Subsidence monitoring of the cap will commence.	
Subsoil and topsoil is replaced on the cap after the cessation of subsidence monitoring. This layer will be a minimum of 1.7 m thick.	

7.3.1 Alternative closure designs considered

Underground

Mining Plus (2015) was engaged to assess the costs and practicalities of a shallow underground development to store radioactive waste in a secure environment, being separate to the main waste isolation cell system proposed. The underground workings considered were to be just below the silcrete layer and would be accessed by a box-cut. A main drive provides access to shorter 'room' drives. Use of the silcrete as the sole 'roof' is not considered practical as the silcrete is of variable thickness. The underside of the silcrete is also too close to the surface for storage of higher activity radioactive wastes.



The method of excavation would be by mini-excavator fitted with a rotating bit, with the broken material mucked out and trammed to the surface by front end loader. Due to the ground conditions, the mining can only progress one metre before the walls and roof must be shot-creted. The cost of such a development method was calculated and determined to be un-economical.

Vertical shaft sinking

Vertical shaft sinking was also assessed by Mining Plus (2015) as a method of creating secure storage of smaller quantities of radioactive waste. A conceptual design is provided in Appendix A.4. The shafts would be constructed either using an auger type piling rig or by conventional means, with the shafts being un-lined when used for waste storage. Waste in drums would be lowered into the shafts, with placement able to be halted between waste deliveries and the active shaft temporarily closed with a steel cap at the surface and / or a poured concrete plug on the last layer of waste. There is little cost difference between the two methods and diameters of shafts. Mobilisation costs for shaft sinking are a significant portion of the cost for this method of disposal and the unit cost calculated above is based upon a large number of shafts being constructed during the one mobilisation event.

LEGEND - Cell Backfill

Mottled clays compacted to 95%mmdd

Mixed laterite and silcrete and clayed sand compacted to 95%mmdd, Max particle size 40mm

Waste sand backfilled around drums/bags compacted to 90%mmdd

LEGEND - Existing Ground

Clayed sand

Laterite

Silcrete

Mottled clays (iron stained kaolinised granite)

Kaolinised granite

Unweathered granite

7.4 Validation of waste cell designs

The Safety Case and Safety Assessments drive the safety of the Facility and the appropriate cell design to ensure humans and the environment are not exposed to unacceptable risks over geological time. As part of the continual improvement and evolving best practice, Tellus will validate the cell design by conducting soil temperature and moisture monitoring, and conducting vegetation establishment trials on cell caps. These are described in more detail below.

7.4.1 Soil temperature and moisture monitoring

Soil moisture probes and other instrumentation have been installed at various depths above the silcrete to establish soil moisture profiles during rain events and subsequent dry periods. This data will be used to calibrate any unsaturated flow models that are developed in the future.

7.4.2 Trial covers

Tellus will consider conducting trials involving the creation of a domed kaolin cap (but without the waste cell beneath it), and experimenting with replacement of topsoils and attempting to grow vegetation under different variables (e.g. fertiliser rates, water application, seed mix combinations, weed management).

7.5 Cells rehabilitation schedule

For the purposes of closure in this WFDCP, the surface of each cell will be domed, with a 1 in 20 gradient, and have in place a layer of topsoil and subsoil to a height of up to 5m AHD above the surrounding land surface, and the landform will be integrated with natural contours to the extent possible.

It is anticipated that nominally one cell will be completed and closed each year during the operations phase (25 years). Table 7–3 shows the multi-staged schedule for backfilling, capping and monitoring each cell as the operation progresses. It is envisaged that each cell will be monitored for 10 years for subsidence, topsoil replaced and vegetated, and that vegetation monitored for 10 years.

At the end of the monitoring period, it is assumed that the completion criteria (Table 4–1) will be met. As per the schedule in Table 7–3, the first cell will be considered ‘closed’ in year 21 and the last cell will be considered ‘closed’ in year 45. Those cells in Table 7–3 that will continue to be monitored during the Post Closure Management Period (described further in Section 8) are listed in *italics*.

Table 7-3 Cells rehabilitation schedule

Cell	Backfilled and Domed Cap	Subsidence Monitoring (10 years)	Topsoil Replacement and Vegetation Establishment	Revegetation Monitoring (10 years)	Predicted Year Completion Criteria Met
1	Year 1	Year 1 -11	Year 11	Year 11 -21	Year 21
2	Year 2	Year 2-12	Year 12	Year 12-22	Year 22

Cell	Backfilled and Domed Cap	Subsidence Monitoring (10 years)	Topsoil Replacement and Vegetation Establishment	Revegetation Monitoring (10 years)	Predicted Year Completion Criteria Met
3	Year 3	Year 3-13	Year 13	Year 13-23	Year 23
4	Year 4	Year 4-14	Year 14	Year 14-24	Year 24
5	Year 5	Year 5-15	Year 15	Year 15-25	Year 25
6	Year 6	Year 6-16	Year 16	Year 16-*26*	*Year 26*
7	Year 7	Year 7-17	Year 17	Year 17-*27*	*Year 27*
8	Year 8	Year 8-18	Year 18	Year 18-*28*	*Year 28*
9	Year 9	Year 9-19	Year 19	Year 19-*29*	*Year 29*
10	Year 10	Year 10-20	Year 20	Year 20-*30*	*Year 30*
11	Year 11	Year 11-21	Year 21	Year 21-*31*	*Year 31*
12	Year 12	Year 12-22	Year 22	Year 22-*32*	*Year 32*
13	Year 13	Year 13-23	Year 23	Year 23-*33*	*Year 33*
14	Year 14	Year 14-24	Year 24	Year 24-*34*	*Year 34*
15	Year 15	Year 15-25	Year 25	Year 25-*35*	*Year 35*
16	Year 16	Year 16-*26*	*Year 26*	*Year 26-36*	*Year 36*
17	Year 17	Year 17-*27*	*Year 27*	*Year 27-37*	*Year 37*
18	Year 18	Year 18-*28*	*Year 28*	*Year 28-38*	*Year 38*
19	Year 19	Year 19-*29*	*Year 29*	*Year 29-39*	*Year 39*
20	Year 20	Year 20-*30*	*Year 30*	*Year 30-40*	*Year 40*
21	Year 21	Year 21-*31*	*Year 31*	*Year 31-41*	*Year 41*
22	Year 22	Year 22-*32*	*Year 32*	*Year 32-42*	*Year 42*
23	Year 23	Year 23-*33*	*Year 33*	*Year 33-43*	*Year 43*
24	Year 24	Year 24-*34*	*Year 34*	*Year 34-44*	*Year 44*
25	Year 25	Year 25-*35*	*Year 35*	*Year 35-45*	*Year 45*

7.6 Subsidence monitoring

For the first 10 years of the cell cap being in place (without topsoil or vegetation), it will be monitored for subsidence. This would be evident by:

- Slumping of the cap.
- Cracking or unusual deformation of the cap.
- Ponding of water on the domed cap or development of preferential pathways leading to erosion or rilling.

The 10 year monitoring period for cap stability was selected based on information on the exposed clay caps at the adjacent IWDF, where only one clay cap exhibited minor and localised subsidence and this occurred within 5 years. For conservatism, Tellus has adopted an extended initial subsidence monitoring period of 10 years. In addition, advice from Douglas Partners (geotechnical engineers) indicates that over the 10 year period, it is expected that more than 95% of residual settlement will have occurred providing a high degree of confidence that the structure of the waste body is unlikely to undergo any further significant vertical deformation.

In addition, Tellus will place a metallic mesh or grid on top of the clay dome before overlaying the soil so that the profile of the clay dome can be monitored using ground penetrating radar if required after placement of the top soil.

Subsidence monitoring will be undertaken annually from the closure date of each individual cell. Monitoring will consist for taking photographs from a fixed locations and completion of an accurate survey pickup of the cap. Measurements of the erosion of the clay domes (surface geometry, location and depth) and any subsidence features (number and depth) will be recorded. Any cracks/rills will be immediately repaired to return the cap to the correct profile.

7.7 Soil replacement

7.7.1 Methodology

On completion of the 10 year subsidence period and assuming that a geotechnical assessment confirms that the cap is stable, soil will be replaced on the clay caps. If the clay dome is not passed as stable, then an additional period of monitoring or remedial works may be required before the soil cover can be placed.

The maximum height of the soil layer will typically be 1.7 m at the centre of the cap. This will grade at a 3° slope for approximately 100m. From a cell area of 7,200 m^2 the volumes of subsoil (20 cm depth) and topsoil (10 cm depth) available for use will be:

- Topsoil –720 m^3
- Subsoil – 1440 m^3

The topsoil and subsoil are deep yellow sands, described by Landloch (2015a), with the remainder of the soil layer comprised of laterite, silcrete and overburden excavated deeper within the pits. An abundance of this material will be available. The subsoil and topsoil will be replaced on the top of the soil layer, as this material contains nutrients available for plant growth. Topsoil will be ripped ready for seeding/planting.

It should be noted that the topsoil from the construction of cell 11 will be directly placed on cell 1, rather than being stockpiled to improve its viability as a growing medium. This direct replacement will continue (i.e. topsoil from cells 12 to 25 will be replaced on cells 2 to 15). The topsoil from the initial 10 cells will be stockpiled, and managed to maintain a seed bank, and potentially mixed with topsoil being directly replaced to ensure viable topsoil is available to be placed on cells 16 to 25.

7.8 Vegetation establishment and monitoring

7.8.1 Research

Prior to the establishment of vegetation research will be undertaken on the following aspects:

- Research and investigation of successful techniques/methods for revegetation of land in arid climates.
- Research on the species listed in the PER to determine:
    - environmental cues to break dormancy.
    - flowering times.
    - seed collection methods.
    - viability of seed before or after storage.
    - optimum timing of sowing.
    - potential germination rates in the field.
    - germination enhancement technologies.
    - whether irrigation and fertilising would assist growth or be detrimental to overall survival.
    - probable survival rates of the seedlings.
- Research on amendments to the soils, specifically looking at increasing the pH and fertilisty of the Deep Yellow Sands.

As described in Section 7.4.2 trials will be setup to assist research and investigations into the appropriate vegetation cover for the caps.

7.8.2 Establishment

Vegetation will be established in accordance with a documented revegetation establishment procedure. This procedure will also describe the monitoring procedure and performance measures to assess growth and success over time. This procedure will include information on:

- Re-seeding/planting tubestock with species of local provenance. The species list of appropriate native species will be based on the best information available at the time of planting. The current species list is provided in Appendix A.3 of the PER.
- Weed management during revegetation, including mitigation measure for regrowth and competition of weeds with native revegetated species.
- Irrigation of vegetation if required during the establishment phase. The use of irrigation will be avoided as far as possible by selecting local, drought tolerant specifies and planting/seeding during the cooler wetter months.
- Fertilising vegetation during the establishment phase.
- Establishment of analogue vegetation sites in deep yellow sands elsewhere on the mining tenement. An analogue site is an unmined feature against which a mined feature may be compared (DITR, 2006).

7.8.3 Monitoring

Methodology

The methodology appropriate for monitoring vegetation from year 26 to 36 will be based on the considered industry practice at the time. Currently the methodologies used by the industry include:

- **Point / Line intercept** — Uses a large number of observations to estimate cover values with high precision.
- **Quadrat monitoring** – Square or rectangle areas in the vegetation are examined and information regarding cover, frequency and diversity are collected.
- **Landscape Function Analysis** — measures the patchiness and quality of patch zones along a transect.
- **Plotless– vegetation monitoring** — the Point Centered Quarter method estimates density.A set of points (usually positioned along a transect to traverse the area) is initially selected. The area around each point is divided into four 90° quadrants, and the plant closest to the point in each quadrant is identified. The distance between the central point and selected plant in each quadrant is measured, and then averaged across the four to represent the distance at each sample point. At the conclusion of data collection, the average distance for all sample points is calculated (University of Arizona, 2016).
- **Photo–point monitoring** – photos are taken at fixed locations every monitoring event to visually see the change in vegetation.
- **Remote sensing** – a drone or similar may be used to look at the rehabilitation from a 'birds eye view'. GIS data can be collected and compared between monitoring events to see the change in vegetation cover.

- **Relevés method** – a list of plants in a delimited plot of vegetation, with information on species cover and a substrate and other abiotic features of the plot (Minnesota Department of Natural Resources, 2013).
- **Diameter at breast (DBH) height** – used as a measure of tree maturity, involves measuring the breast and height of a tree.

The method chosen will be part of an integrated approach designed for the specific climate of the site. The method or combination of methods will be repeatable (and auditable) and supported by studies and scientific literature. The methodology will also be discussed with the regulator prior to implementation.

Quality control

An analogue site is an unmined feature against which a mined feature may be compared (DITR, 2006). Two analogue sites, one in Deep Yellow Sand and one in Red Sandy Duplex soil types will be setup and monitored, as per the same methodology as the rehabilitation sites. The purpose of the analogue sites will be to act as a control site, and used for comparison of monitored parameters.

Monitoring frequency

Monitoring of all revegetated areas will be conducted on an annual basis for the first three to five years to determine initial establishment, then on a reduced frequency until completion criteria are achieved. Ideally, monitoring should be conducted at the same time each year following rains.

Reporting of results

Results will be graphed against historical monitoring results. Graphs and raw data will be included in Annual Environmental Reports to the DMP. An assessment of the results of the monitoring in relation to achieving the completion criteria will be discussed in Annual Environmental Reports for each revegetated area.

Remedial strategy

Targeted remediation of poor–performing rehabilitation areas may be necessary. Tellus will consult a botanist to determine the appropriate remedial strategy for rehabilitation should the results of the monitoring not be trending towards the completion criteria. Remedial strategies may include; amendments to the soil, more seed broadcasting, weed management and feral animal controls.

7.9 Radiation monitoring

The aim of the monitoring programme is to:

- Demonstrate regulatory compliance.
- Assessment of the efficiency of work practices and engineering controls in preventing and limiting employee and public exposure to radiation.
- Provide data to enable knowledgeable radiation protection decision-making.

The general procedures are:

- To conduct area gamma and airborne activity surveys to define general baseline radiation levels before the project is started.
- To conduct area gamma and airborne activity surveys before finalising the preliminary earthworks phase to confirm that sufficient material has been removed and to confirm no spread of contamination to neighbouring areas
- To comprehensively monitor people who work in the areas by:
    - Individual gamma monitoring to determine external γ-radiation.
    - Random personal dust sampling to determine airborne radioactivity.
- To conduct assessments of doses received by employees and the critical group.
- To ensure action levels are not exceeded.
- To investigate and correct any situation that results in an action level being exceeded.
- To adopt practical preventive measures at all times to limit the exposure of all persons.

The purpose of the Environmental program is to ensure that radiological impact to the local environment and to members of the public is minimal. This program is usually accomplished by area monitoring (dust and water monitoring, and area γ-surveys).

The environmental monitoring program is adapted based on on-going interpretation of results and risk assessments before disposal and waste acceptance. The following environmental radiation monitoring programme (Table 6) will be followed as a minimum to ensure that the operations have no detrimental effect on the environment.

Table 7-4 Radiation monitoring schedule summary

Monitoring type	Type of monitoring	Type of radiation	Pre-operational	Baseline (operational)
Dust Monitoring	Environmental high volume dust samples	LLA	1/year from 6 representative locations.	2/year from representative locations.
Radon	Track etch	RnDP	1/ year from 3 locations.	2/year for first 3 years of operation – then as per determined risk.
Area γ-Monitoring	Pre disposal background gamma levels	γ-survey	Pre clearance survey before cell is mined.	Pre disposal (mined out pit), after disposal and after final capping.
	Boundary gamma surveys	γ-survey	Once off.	Annually.
	Equipment contamination clearance	α, β, γ-survey		As required before equipment that might be contaminated leave site.
Waste storage	Radiation store	γ-survey		Quarterly.
	Stockpiles	γ-survey		2/year.

7.10Groundwater monitoring

Annual monitoring of static groundwater levels will be conducted in seven groundwater bores (listed in Table 7–4). Results will be graphed against historical monitoring results. Graphs and raw data will be included in Annual Environmental Reports to the DER. If sufficient groundwater is detected to allow sampling, samples will be collected and analysed for suite of parameters, based on the available information at the time on what wastes have been stored.

Table 7-5 Groundwater Monitoring Bores

Bore ID	Location (Zone 51J) Easting	Northing	Depth (mAHD)	(mbtoc)	Screened Interval (mAHD)	(mbtoc)	Lithology of screened inteerval
SRMB146	219888	6637794	458	30.5	434.38 – 428.38	24.5 – 30.5	Kaolinite and deeply weathered granite
SRMB147	219890	6638007	458	20.6	444.28 – 438.28	14.6 – 20.6	Kaolinite (saprock)
SRMB148	219702	6637808	457	24.3	439.7 – 433.7	18.3 – 24.3	Kaolinite (weathered granite)
SRMB149	220238	6637886	463	22.9	447.25 – 441.25	16.9 – 22.9	Weathered granite
SRMB150	219372	6638392	455	49	416.07 – 407.07	40 – 49	Weathered and fresh granite
SRMB151	219681	6638402	457	44.7	418.88 – 412.88	38.7 – 44.7	Moderately to slightly weathered granite
SRMB152	219499	6637606	455	38.4	423.14 – 417.14	32.4 – 38.4	Weathered granite

7.11 Fencing

Fencing will be maintained around the cells for the Operations Phase (i.e. years 0–25). Weekly inspections of the perimeter fence will be undertaken to carry out maintenance where required. After cyclonic events or heavy rainfall events, the perimeter fence will be checked and maintenance completed if required.

7.12 Underground storage area closure work program

At the cessation of waste disposal underground the entry points to the underground storage area will be made safe and secure and fenced off with signage to prevent restricted access. Exposed ground would be ripped, vegetated and fertilised and then monitored for a period of 10 years.

A description of the rehabilitation schedule for the underground storage area is outlined in Table 7–5.

Table 7-6 Underground storage area rehabilitation schedule

Task	Year
Last use of the underground storage area	Year 25
All entry points to the underground storage area will be made safe and secure and fenced off with signage to prevent restricted access.	Year 25
Ripping of soil surface	Year 26
Spread of growth medium	Year 26
Establishment of vegetation	Year 26
Monitoring of vegetation (10 years)	Year 26– Year 36
Completion Criteria Met	Year 37

7.13 Storage of Records

The *Code of practice for the near-surface disposal of radioactive waste in Australia* (NHMRC, 1992) details the records and inventory keeping required:

Detailed records shall be kept by the operator and by the appropriate authority of all waste consigned to, and received at the facility. For each shipment the waste generator, the type of waste, its volume and weight, and the nature and concentration of nuclides in the waste shall be recorded. Any conditioning of the waste shall also be recorded.

Details of any accidents and incidents at the facility shall be kept together within information on the impact on personnel, the public and environment.

The occupational exposure records of all employees exposed to radiation in the course of their work shall be retained in a form specified by the appropriate authority. All data from environmental and area monitoring at and around the facility shall also be retained.

Furthermore site records shall be kept at least until the end of the institutional control period in two widely separated locations, one of which shall be the appropriate State or Federal government archives, and shall include:

- The location of any disposal structures.
- The location of the waste packages or containers within the structures and the date of their emplacement.
- Detailed of the contents of waste packages or containers.
- Details of the backfilling and cover materials.

Detailed records regarding each waste load (type of waste, its volume and weight, the nature and concentration of nuclides and any conditioning of the waste) will be entered and monitored through Tellus' electronic tracking system on a daily basis.

Tellus will operate two management systems in which details of any accidents and incidents at the Facility will be recorded:

- Occupational Health and Safety Management System (OHSAS 18001 compliant) – records on impacts to workers or the public and data on exposure to radiation will be retained in this system.
- Environmental Management System (ISO 14001 complaint) – records on impacts to the environment, environmental and area data will be retained in this system.

Tellus also operate a Quality Management System (ISO 9001 compliant) which will be implemented during the operation of the Facility to ensure consistent documentation, record keeping and business processes.

Site records will be maintained electronically in the three management systems listed above during the operation of the site.

It is envisaged that the records pertaining to the operation and closure of the site will be provided in hardcopy and electronic form to the key regulatory agencies and the State Archive.

8 POST CLOSURE MANAGEMENT PHASE

8.1 Status Year 26 to 45

On the basis that waste disposal will be completed by Year 25, the status of the following elements at this point of the project lifecycle is as follows:

- Subsidence monitoring will be in progress for 10 cells, and this monitoring will continue in accordance with Section 7.5 until year 35.
- Topsoil replacement will be in progress for 10 cells, in accordance with the soil management procedure.
- Vegetation establishment will be in progress for 10 cells, in accordance with the revegetation establishment procedure.
- Vegetation monitoring will be in progress for 20 cells, conducted in accordance with Section 7.8.3 and this monitoring will continue until year 45.
- All infrastructure on the site will have been decommissioned and the associated impact footprints rehabilitated in accordance with the Mine Closure Plan. The exception is the front office and amenities building, radioactive waste warehouse, water pipeline and associated infrastructure (e.g. reverse osmosis system, water tanks, pumps) which will remain onsite until decommissioned (see Section 8.2).

Figure 8–1 provides a conceptual layout of the site in Year 26 to 45.

The main activities towards the end of the Post Closure Management Phase are the decommissioning of the Facility and handover of the site to the State Government. These activities are described in further detail below.

8.2 Waste facility decommissioning program

8.2.1 Water pipeline and associated infrastructure

Approaching the time for handover of the Facility to the State Government a decision will be made regarding whether the water pipeline is removed and how it is removed or whether it is to remain in place. A section of the water pipeline traverses the ex–Jaurdi pastoral lease, and if removal of the pipeline is the chosen option, it will need to be discussed with DPAW to minimise impacts to the surrounding vegetation.

The rehabilitation activities for the water pipeline route and footprints of associated equipment would include ripping of the soil surface and seeding or planting with tubestock. The area would be irrigated and fertilised in accordance with the planted species requirements for growth. Equipment (pumps, tanks etc.) would be removed from the site.

Figure 8–1 Infrastructure remaining onsite

8.2.2 Fences

All fences on the site will be taken down and removed from the site at year 45. Fences will only remain in place if agreed to with the appropriate authority for institutional control.

8.2.3 Administration building

Approaching the time for handover of the Facility to the State Government a decision will be made regarding whether the administration building, which will include bathroom and kitchen facilities, will be removed or remain for the ICP.

The weighbridge and gate at the entrance to the Facility will be dismantled and removed. The internal parking and roads will be broken up and the bitumen removed. Both areas will be spread with topsoil, deep ripped and revegetated.

8.2.4 Radioactive waste warehouse

The radioactive waste warehouse will be decommissioned (all equipment removed) and the concrete pad removed, topsoil ripped and vegetation established.

8.2.5 Financial provisioning

Financial provisioning information for the Facility decommissioning program is provided in Table 8–1. Cost estimates were calculated in an MS® Excel spreadsheet as part of Tellus' overall financial planning of the project, and the final estimates are provided in Table 8–1.

The costings provided are based on the size of areas (as defined during the pre–feasibility phase of the project development) and 2016 rates. Rates account for; supply, labour, construction equipment and freight. The rate multiplied by the size of the area (quantity) provides a cost estimate. This cost estimate is then considered in terms of growth over 45 years (i.e. growth of the quantity) to account for any change to the size of areas to be closed.

Tellus recognise the importance of updating the financial provisioning cost estimates with each revision of the WFDCP, to ensure closure is included in Tellus annual financial budgets.

8.2.6 Monitoring of revegetated footprints

Monitoring of revegetation footprints will occur during the ICP under the control of the appropriate authority.

8.3 Handover to State Government

8.3.1 Transfer arrangements

Tellus will maintain a package of insurances to cover an agreed set of circumstances based on an independent risk assessment which identifies all credible risks and the cost of remedial works that would be required as consequence of these risks being evidenced. Tellus will provide the necessary funding to transition these insurance arrangements to the State Government for the term of the ICP.

Stored electronic records (required by Section 7.13) will be transferred to the state archives and federal archives, or to the location agreed to between Tellus and the State Government.

8.4 Financial provision during ICP

Tellus propose to transfer responsibility of the site to State Government with the appropriate financial resources to cover ongoing management through the ICP. Tellus will transfer an agreed sum of money into an escrowed fund to cover the cost of managing the site. The amount of funding transferred will be determined based on an independent assessment by a competent consultant and will be agreed with the relevant Government agencies.

9 INSTITUTIONAL CONTROL PERIOD – STATE GOVERNMENT MANAGEMENT

9.1 Status Year 46 to 325

The status at year 46 assumes a handover of the Facility has occurred to the appropriate authority within the State Government. The State Government will complete the following activities during the ICP (defined in Section 9.2):

- Vegetation monitoring of the Facility infrastructure footprints until the vegetation meets the completion criteria outlined in Table 4–1.
- Continue radiation and groundwater monitoring of the Facility.
- Restrict public access to, or alternative use of, the Facility.
- Maintain records of the wastes buried at the Facility.
- Assess land use post–institutional control period to ensure it is compatible with stored intractable waste.

9.2 Definition of institutional control

Institutional control is defined by the *Code of practice for the near–surface disposal of radioactive waste in Australia* (NHMRC, 1992) as the control of a former waste disposal site by the appropriate authority in order to restrict access to and use of the site, and to ensure an on-going knowledge that the site has been used for the disposal of radioactive waste.

The ICP, as defined by NHMRC (1992), is the period following closure of the disposal facility where public access to, or alternative use of, the site shall be restricted for a predetermined period of time. The ICP shall be established before the commencement of disposal of operations (i.e. disposal of radioactive waste) and should not be less than 100 years.

The appropriate authority to determine the institutional control period for Sandy Ridge is the Radiological Council of Western Australia. As per NHMRC (1992) the Radiological Council of Western Australia may vary the institutional control period according to the usage of the facility.

It should be noted that the institutional control relates to radioactive waste only. Should radioactive waste disposal at Sandy Ridge never eventuate, then the site would not be subject to an ICP.

9.3 Appropriate authority

As Tellus is a private company and does not own the land, at an agreed milestone in the ICP, responsibility for the Sandy Ridge facility is proposed to be transferred to the Western Australian Government. The site will then be managed by a government agency determined by the State Government. This agency would then be recognised as the appropriate authority for institutional control. As part of the transfer of responsibility from Tellus to the State Government, Tellus will also provide ample funding through an escrowed fund arrangement to cover management costs likely to be incurred by Government.

Government is the only practical option to be the appropriate authority for institutional control given:

- The nature of the wastes is such that they must be contained securely for geological time.
- The extended length of the institutional control period (100 to 300 years).
- The land in question is a Crown Reserve.
- The Government exists in perpetuity, whereas it is feasible or even likely that at some future date Tellus may no longer exist.

The Government therefore is in the best position to restrict access to and use of the site, and to ensure on-going knowledge is retained in state archives for future populations to access as required.

9.4 Monitoring requirements

9.4.1 Vegetation monitoring

Vegetation monitoring will be required of the cell caps and the footprints of the facility infrastructure (Section 9.4.1). The methodology for vegetation monitoring will be in accordance with best practice at the time monitoring is to be carried out (i.e. in five decades time).

9.4.2 Radiation monitoring

Refer to Section 7.9

9.4.3 Groundwater monitoring

Annual monitoring of static groundwater levels in seven groundwater bores (listed in Table 9–1) will be conducted. Results will be graphed against historical monitoring results. Graphs and raw data will be included in Annual Environmental Reports to the Reserve manager.

Table 9-1 Groundwater monitoring bores

BORE ID	LOCATION (Zone 51J)		DEPTH		SCREENED INTERVAL		LITHOLOGY OF SCREENED INTERVAL
	EASTING	NORTHING	(mAHD)	(mbtoc)	(mAHD)	(mbtoc)	
SRMB146	219888	6637794	458	30.5	434.38 – 428.38	24.5 – 30.5	Kaolinite and deeply weathered granite
SRMB147	219890	6638007	458	20.6	444.28 – 438.28	14.6 – 20.6	Kaolinite (saprock)
SRMB148	219702	6637808	457	24.3	439.7 – 433.7	18.3 – 24.3	Kaolinite (weathered granite)
SRMB149	220238	6637886	463	22.9	447.25 – 441.25	16.9 – 22.9	Weathered granite
SRMB150	219372	6638392	455	49	416.07 – 407.07	40 – 49	Weathered and fresh granite
SRMB151	219681	6638402	457	44.7	418.88 – 412.88	38.7 – 44.7	Moderately to slightly weathered granite
SRMB152	219499	6637606	455	38.4	423.14 – 417.14	32.4 – 38.4	Weathered granite

9.5 Management requirements

9.5.1 Restrict Public Access

The State Government will need to put in place access restrictions to avoid the public utilising the site. The mechanism to achieve this will need to be discussed within government to find the appropriate solution at the commencement of the State Government's management of the Facility.

9.5.2 Records Storage

Maintain and make publically available stored records kept by Tellus (see Section 7.13). These records should be held for access by future generations to ensure knowledge is passed on regarding the location of buried chemical wastes. This will avoid potential human health impacts long–term by the accidental excavation of wastes.

9.5.3 Post–institutional control land use

Any proposed new use for the former site should be compatible with the presence of intractable chemical waste at greater than 7 m beneath the surface.

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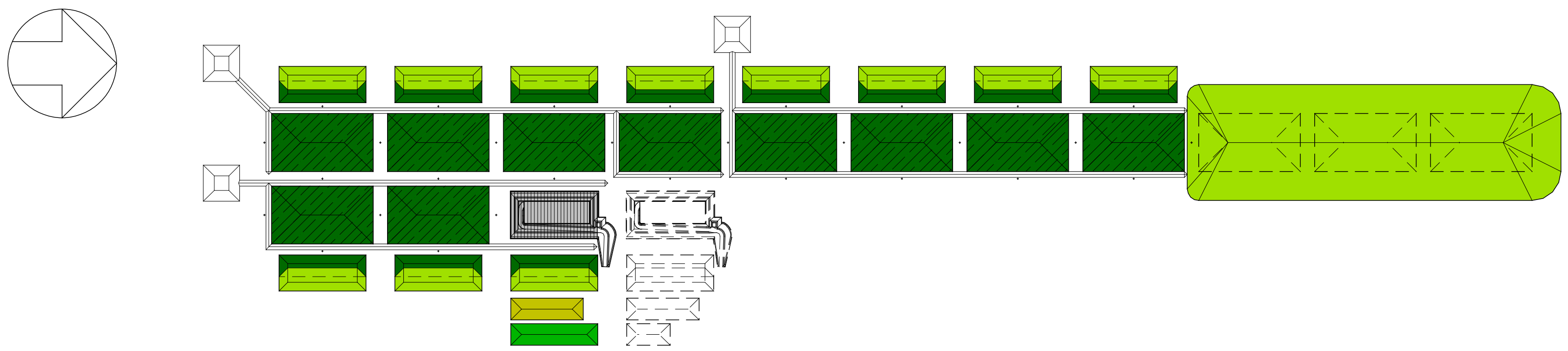
APPENDICES

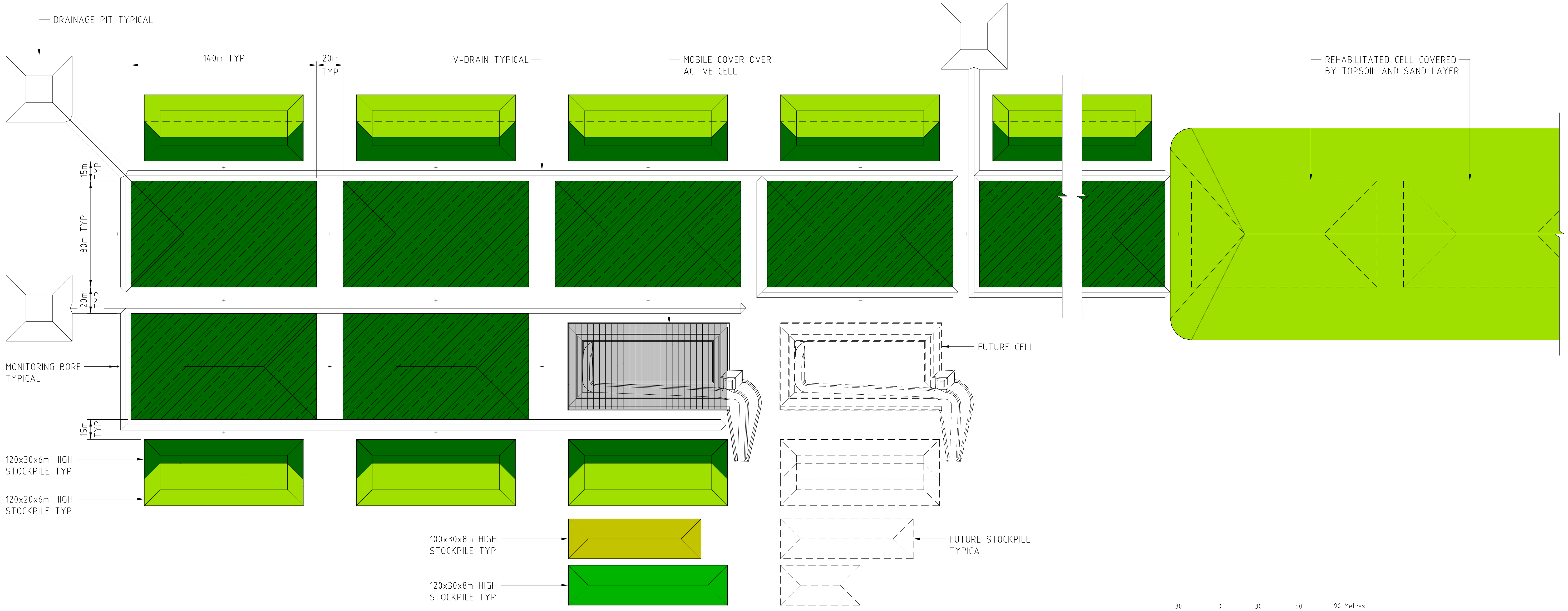
A.1 General arrangement of cells



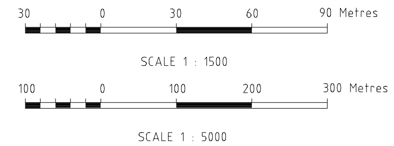
OVERALL LAYOUT PLAN
SCALE 1:5000

NOTES
1. LAYOUT DESIGN IS PRELIMINARY ONLY.

LEGEND - STOCKPILES AND BACKFILL
- MOTTLED CLAYS
- YELLOW SAND AND TOPSOIL
- CRUSHED SILCRETE AND LATERITE
- KAOLINISED GRANITE
- MOTTLED CLAYS COMPACTED TO 95%MMDD BACKFILL



LAYOUT PLAN
SCALE 1:1500



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CLIENT DRG No.

REV	BY	DATE	DESCRIPTION	CHKD	ENG
A	BK	15.09.15	ISSUED FOR INTERNAL AND CLIENT REVIEW	JL	IWB

REF DRG No	TITLE

CLIENT: TELLUS

ONYX PROJECTS

Level 1, Parmelia House | 191 St Georges Terrace | Perth, WA 6000 | Australia
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	BY	DATE
DRAWN	B KLEMICK	08.09.15
CHKD		
DES ENG		
PROJ ENG		
CLIENT		

TITLE
TELLUS SANDY RIDGE
PRE-FEASIBILITY STUDY
WASTE ISOLATION CELL
OVERALL LAYOUT

PROJECT No	SIZE	SCALE	DRG No	REV
C5409	A1	1:1500	C5409-6310-CE-005	A

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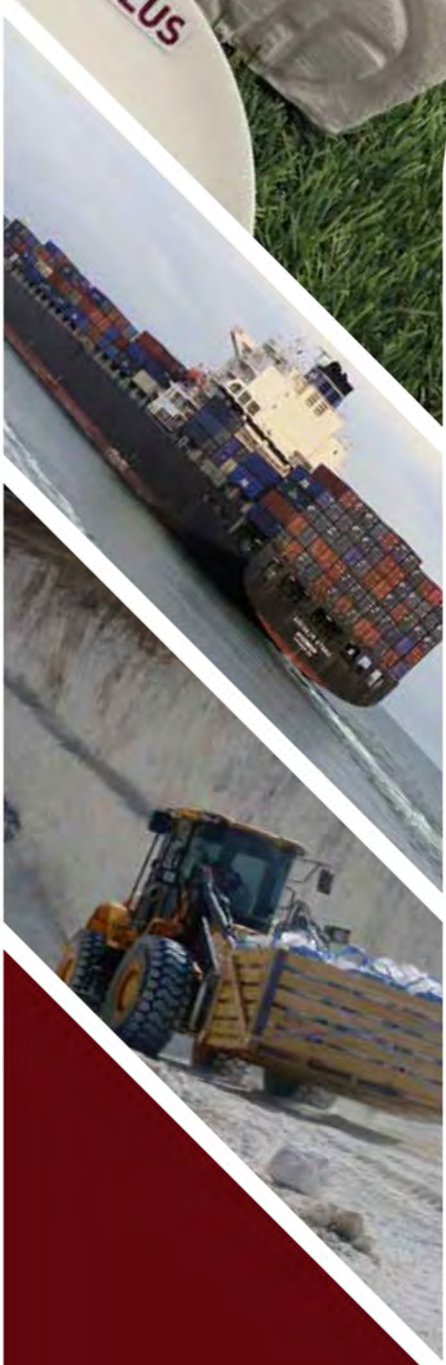
A.2 Risk matrix and assessment



TELLUS

Sandy Ridge Facility
Environmental Risk Assessment

June 2016

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SANDY RIDGE FACILITY ENVIRONMENTAL RISK ASSESSMENT

Draft Report | June 2016

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DISTRIBUTION

Report File Name	Report Status	Author	Date	Distribution
Environmental Risk Assessment –V0.1	V0.1 (Draft)	Aurora Environmental	15 February 2016	Tellus Holdings Ltd
Environmental Risk Assessment –V0.2	V0.2 (Draft)	Aurora Environmental	12 April 2016	Tellus Holdings Ltd
Environmental Risk Assessment	vA	Tellus Holdings Ltd	7 June 2016	OEPA

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All care and diligence has been exercised in interpreting data and the development of environmental assessment and recommendations presented in this report. In any event, Tellus accepts no liability for any costs, liabilities or losses arising because of the use of, or reliance upon, the contents of this report.

ABBREVIATIONS

ADT	Articulated dump truck
Bq/g	Bequerels per gram
DotE	Department of the Environment (Cwlth)
DG	Dangerous goods
DPAW	Department of Parks and Wildlife (WA)
EMS	Environmental Management System
EP Act	*Environmental Protection Act 1986* (WA)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cwlth)
JSA	Job safety analysis
mm	millimetre
PEC	Priority Ecological Community
PER	Public Environmental Review
PPE	personal protective equipment
QA	quality assurance
QC	quality control
TEC	Threatened Ecological Community

1 INTRODUCTION

Tellus Holdings Limited (Tellus) proposes to construct and operate the Sandy Ridge Project. The details of the Sandy Ridge Project are provided in the *Sandy Ridge Project Public Environmental Review* (PER) (Tellus, 2016).

The environmental risks associated with the operational aspects of the project have been assessed by the project team at a workshop. The outcomes of the workshop are documented in this report.

Risks associated with closure were addressed at a separate workshop. The outcomes of that workshop are presented in the Mine Closure Plan and Waste Facility Decommissioning and Closure Plan. These plans are appended to the PER.

2 METHODOLOGY

Tellus adopted the international (*ISO 31000:2009*) and national (*AS/NZS ISO 31000:2009*) (SAI Global, 2009) standard processes for managing environment–related risks. An environmental risk assessment has been undertaken for all operational aspects of the project, in accordance with the procedures outlined in *AS/NZS ISO 31000:2009 Risk Management–Principles and Guidelines* and the handbook *HB 203:2012 Managing Environment–Related Risk* (SAI Global, 2012), using Tellus' Risk Assessment Matrix (AppendixA.1). The risk assessment process is illustrated in Figure 2–1.

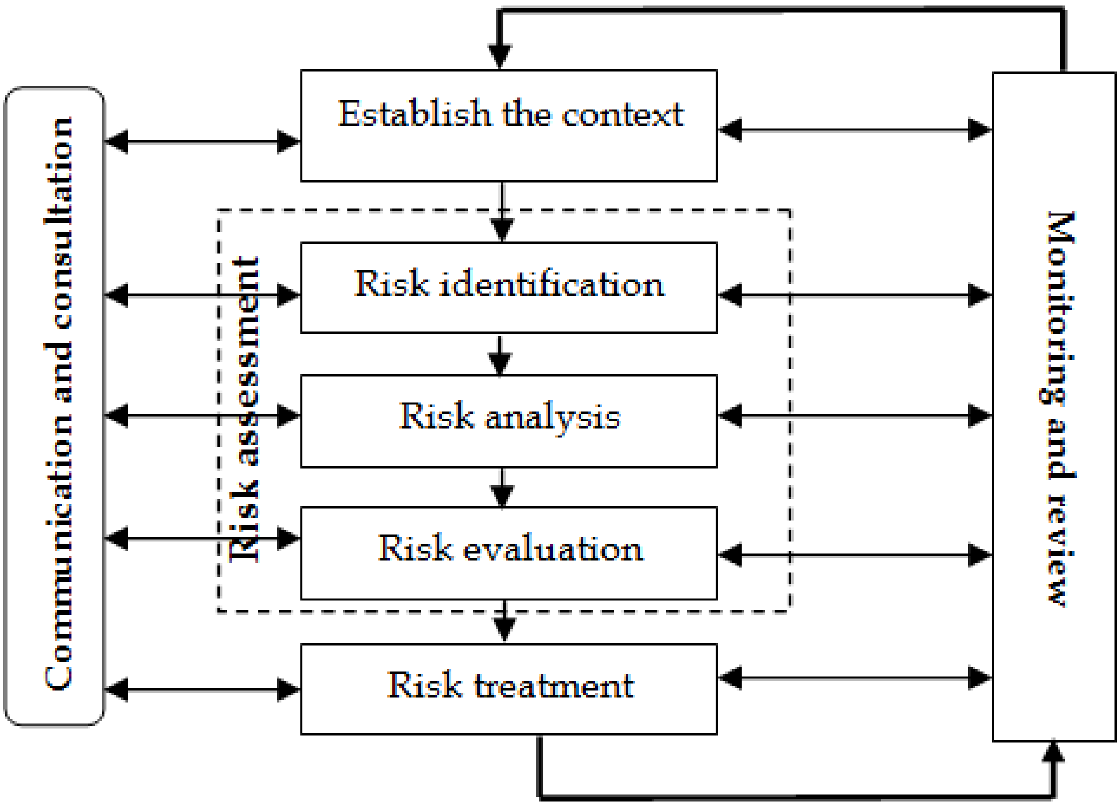


Figure 2–1 Risk assessment process as outlined in HB 203:2012

Each step of the process is described below.

3 ESTABLISH THE CONTEXT

As the project is proposed to be located within Western Australia, the definition of 'environment' for the purpose of the environmental risk assessment was the definition provided under the Western Australian *Environmental Protection Act 1986* (EP Act):

environment*, subject to subsection (2), means living things, their physical, biological and social surroundings, and interactions between all of these (*Part 1, section 3, subsection 1).

For the purposes of the definition of environment in subsection (1), the social surroundings of man are his aesthetic, cultural, economic and social surroundings to the extent that those surroundings directly affect or are affected by his physical or biological surroundings (Part 1, section 3, subsection 2).

The project is also being assessed by the Commonwealth Department of the Environment (DotE) under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Section 528 of the EPBC Act defines environment to include:

(a) ecosystems and their constituent parts, including people and communities; and

(b) natural and physical resources; and

(c) the qualities and characteristics of locations, places and areas; and

(d) Heritage values of places; and

(e) the social, economic and cultural aspects of a thing mentioned in paragraph (a), (b), or (c).

The EPBC Act's definition for environment was also considered in establishing the context of the risk assessment.

The glossary of other terminology used during the environmental risk assessment was as per *HB 203:2012 Managing Environment–Related Risk* as listed below:

Consequence	includes cascade effects and impacts to the organization's business and activities arising from environmental-related issues (e.g. regulatory fines, clean-up costs, and damaged reputation as well as enhanced reputation, continued licence to operate, and regulatory approvals).
Environmental Aspect	element of an organization's activities, products or services that can interact with the environment.
Environmental impact	any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization's activities, products or services.
Hazard	source of potential harm.

Likelihood	chance of something happening, whether defined, measured or determined objectively or subjectively, qualitatively or quantitatively, and described using general terms or mathematically.
Risk	the effect of uncertainty on objectives.
Risk Source	a tangible or intangible element that alone or in combination has the intrinsic potential to give rise to risk.

4 RISK ASSESSMENT

4.1 Risk identification

The sources of risks, environmental aspects and potential environmental impacts, as defined by *HB 203:2012* were identified in a workshop attended by the Tellus Project Leader, Tellus Environment and Approvals Manager, Tellus Engineer, and Aurora Environmental representatives. The identified environmental aspects were categorised into 'planned' that is those aspects which Tellus know will occur during the project, and those that are 'unplanned' and may credibly occur during the project, but which Tellus has no control over the frequency of occurrence. The identified potential environmental impact is based on the 'worst–case' credible impact.

4.2 Risk analysis

Qualitative risk analysis was used to evaluate the significance of the likelihood of the consequence (Table 4–1). Analysis of the inherent risk was undertaken assuming no management/mitigation controls were in place. The group then discussed appropriate management and mitigation measures that would be implemented to reduce the likelihood or consequence, and then analysed the final residual risk.

Table 4–1 Environmental risk register

Risk Number	Environmental Aspect	Sources of Risk (Hazard)	Potential Environmental Impact (Worst case)	Pre–management risk	Management and Mitigation Measures	Post–management Risk		Residual risk
						Likelihood	Consequence	
1	**Transport of hazardous/intractable waste.**	Chemical spill (40 t) from the shipping container. Chemical spill onto roads.	Death and/or acute or chronic illness in humans and biota exposed to the spill.	Extreme	Waste packaged in bulka bags/drums. Bulka bags/drums transported inside shipping container. Shipping container securely fastened to truck. Dangerous goods (DG) rated trucks (e.g. better brakes, rollover systems) are used only. Trucks travel on sealed roads or controlled site access roads. Transport contractor on Tellus Register of Approved Transporters. Audits of transport contractor's procedural controls. For high risk loads (e.g. arsenic trioxide) individual risk assessment and transport management plan. Emergency Response and Management Plan.	Rare	Catastrophic	High
2	**Explosions.**	Fuel storage facility, storage and use of gas. Diesel fuel tank and piping reticulation. Explosives magazine.	Degradation of air quality (localised). Death/injury of humans and biota within the vicinity of the blast zone or in the path of the fire. Creates bushfire.	Extreme	Fuel storage facilities and systems designed to meet relevant Code. Inspection to ensure compliance including maintenance. Firebreaks. Firefighting equipment. Operational procedures. Hot work permits. Restricted access to the explosives store (i.e. must hold shot firer licence).	Rare	Major	High
3	**Transport of hazardous/intractable waste.**	Truck crash.	Death and injury to humans.	High	Trucks travel on sealed main roads only. Transport contractor on Tellus Register of Approved Transporters. Well maintained trucks. Approved, experienced and licensed drivers. Audits of transport contractor's procedural controls. Emergency Response and Management Plan. Police, emergency services.	Rare	Catastrophic	High
4	**Transport of hazardous/intractable waste.**	Chemical spill (e.g. flyash/ SPL) on the road, into surrounding environment (e.g. river).	Death and/or injury to fauna and flora.	High	Waste packaged as appropriate to level of hazard. Bulka bags/drums transported inside shipping container. Shipping container securely fastened to truck. DG rated trucks (e.g. better brakes, rollover systems) are used only. Trucks travel on sealed roads or	Possible	Moderate	High

Risk Number	Environmental Aspect	Sources of Risk (Hazard)	Potential Environmental Impact (Worst case)	Pre–management risk	Management and Mitigation Measures	Post–management Risk Likelihood	Post–management Risk Consequence	Residual risk
					controlled site access roads. Transport contractor on Tellus Register of Approved Transporters. Audits of transport contractor's procedural controls. For high risk loads (e.g. arsenic trioxide) individual risk assessment and transport management plan. Emergency Response and Management Plan.			
5	**Transport of hazardous/intractable waste.**	Collision with native fauna.	Road kill of Threatened/Priority fauna.	High	Trucks travel on sealed main roads only. Transport contractor on Tellus Register of Approved Transporters. Well maintained trucks. Approved, experienced and licensed drivers. Audits of transport contractor's procedural controls. Report to DPAW and DotE. Where feasible control speed and use headlights.	Possible	Moderate	High
6	**Creation of mine pits.**	Clearing native vegetation.	Loss of native vegetation.	High	Avoid Priority species. Engineering design to minimise amount of vegetation to be cleared. Supervision of clearing. Operational Procedure. Regular toolbox meeting. Training of Operators.	Almost Certain	Insignificant	High
7	**Creation of firebreak.**	Clearing native vegetation.	Opportunity for weeds to establish.	High	Weed monitoring and removal.	Almost Certain	Insignificant	High
8	**Transport of radioactive waste.**	Radioactive waste spill (200L drum).	Humans within the vicinity of the spill will receive a one off higher dose of radiation above background levels.	High	Small quantities received on average annually. Drums transported inside shipping container. Shipping container securely fastened to truck. Priority given to transporting on heavy haulage routes. For all radioactive waste an individual risk assessment is completed. Disposal permit issued by government. Transport contractor on Tellus Register of Approved Transporters. Audits of transport contractor's procedural controls. Emergency Response and Management Plan. Inform Radiation Health Branch WA.	Unlikely	Moderate	Moderate
9	**Presence of infrastructure (e.g. turkeys nest, landfill, mine voids).**	Attraction of birds, mammals, vermin and feral animals to water source. Fauna falling into pit/cell.	Injury or death of Threatened/Priority fauna.	High	Fencing of contaminated water pond. Fencing around landfill. Covering of landfill once the trench is	Unlikely	Moderate	Moderate

Risk Number	Environmental Aspect	Sources of Risk (Hazard)	Potential Environmental Impact (Worst case)	Pre–management risk	Management and Mitigation Measures	Post–management Risk Likelihood	Post–management Risk Consequence	Residual risk
		Presence of vermin carrying disease at landfill, being eaten by predators.			full. Weekly litter inspection and clean-up. Weekly toolbox meeting. Training of operators. Operational bunding around cell. Ramps into and out of cell. Daily inspection of water ponds for trapped/injured fauna. Daily inspections of access roads for roadkill.			
10	**Naturally occurring events.**	Bushfire.	Injury of workers and site visitors. Toxic smoke plume. Contaminated fire water. Soil contamination.	High	Emergency Response and Management Plan. Low fuel load in woodlands. Firebreaks. Firefighting facilities onsite. Minimal flammable waste, facilities and goods onsite.	Rare	Moderate	Moderate
11	**Introduction of weeds.**	Incoming waste carriers. Incoming supply vehicles and 4wds. Incoming site visitors, staff vehicles. Bird poo.	Establishment of weeds on the site and competition for resources (e.g. water) with native vegetation.	High	Weed monitoring procedures. Inspections of light vehicles and brush downs. Mining plant wash down before its used onsite. Weed removal where necessary.	Likely	Insignificant	Moderate
12	**Accidental fire within infrastructure.**	Flammable goods packed into shipping container. Vehicle fire in cell. Fire in buildings.	Release of toxic gas, adverse health impacts to workers/public/fauna.	High	Equipment maintenance. Fire detection/ suppression systems. Design codes for waste storage. Operational procedures. Regular toolbox meetings. Training of operators. Chemical wastes stored in shipping containers. Use of diesel engines instead of petrol in storage areas. Multiple waste storages areas in container hardstand.	Rare	Moderate	Moderate
13	**Handling of hazardous/intractable waste.**	Chemical spill during offloading of waste from ADT into cell. Chemical spill during manoeuvring of waste package into place in the cell.	Death of worker in the cell.	Extreme	PPE. Training of operators. Regular toolbox meetings. Operating procedures. Restricted access to the cell. Recirculating air throughout cabs. JSAs specific to waste being handled. Equipment maintained. Secondary egress from cell. Everyone in the cell immediately evacuates.	Unlikely	Minor	Low
14	**Creation of cell and waste disposal progressing.**	Surface water runoff into cell.	Generation of leachate and degradation of groundwater.	Extreme	Roof canopy over open cell. Operational bunding around cell, drains into V drain and sump. Levees to divert surface water flow. Backfill around waste packages with high matric suction potential.	Rare	Insignificant	Low

Risk Number	Environmental Aspect	Sources of Risk (Hazard)	Potential Environmental Impact (Worst case)	Pre–management risk	Management and Mitigation Measures	Post–management Risk Likelihood	Post–management Risk Consequence	Residual risk
					Primary containment in place in each waste package (e.g. liner in bulka bag).			
15	**Handling of hazardous/intractable waste.**	Chemical spill during unloading/reloading of waste from/into shipping container in Waste Inspection Shed. Chemical spill during sampling and testing of waste package in laboratory.	Death and/or acute or chronic illness in humans exposed to the spill.	High	Operating procedures. Training of operators. Regular toolbox meetings. PPE. Regular equipment maintenance. Visual assessment. Safety shower. Spill kits. First aiders/first aid kit. Evacuation procedure.	Rare	Minor	Low
16	**Handling of hazardous/intractable waste.**	Vehicle collision with ADT. Loss of containment from shipping container subsequent spill of solids.	Localised soil contamination. Damage to vegetation. Toxic dust dispersal affecting vegetation/fauna off the development envelope.	High	Operating procedures. Training of operators. Regular toolbox meetings. Onsite traffic management. Speed limits. Two-way communications. Regular equipment maintenance. Visual assessment. Spill kit.	Rare	Minor	Low
17	**Handling of radioactive waste.**	NORMs spill during unloading/reloading of waste from/into shipping container in Waste Inspection Shed.	Humans within the vicinity of the spill will receive a one off higher dose of radiation above background levels.	High	Operating procedures. Training of operators. Regular toolbox meetings. PPE. Regular equipment maintenance. Visual assessment. Safety shower. Spill kits. First aiders/first aid kit. Dose meters on workers. Radiation measurements.	Rare	Minor	Low
18	**Handling of radioactive waste.**	Gamma exposure during offloading of waste from ADT into shaft.	Humans within the vicinity of the shaft above with higher dose of radiation above background levels or chemical exposure.	High	Operating procedures. Training of operators. Regular toolbox meetings. Engineering design. Dose meters. Radiation measurements. Exclusion zones.	Rare	Insignificant	Low
19	**Wash down of shipping containers.**	Contaminated wash water washes off the wash down pad. Dust on hardstand from, residual of wash down. Containment overflows during extreme rainfall event. Liner faulty/fails.	Soil contamination.	High	Operating procedures. QA/QC testing on liner. Engineering design (500mm freeboard, ponds sufficient capacity). Shallow monitoring bores. Contain the overflow through secondary sump. Clean-up/disposal of contaminated soil.	Unlikely	Minor	Low

Risk Number	Environmental Aspect	Sources of Risk (Hazard)	Potential Environmental Impact (Worst case)	Pre–management risk	Management and Mitigation Measures	Post–management Risk		Residual risk
						Likelihood	Consequence	
20	**Creation of mine pits.**	Blasting. Physical removal of topsoil, subsoil and kaolin.	Dust emissions affecting workers. Dust emissions settling on plant leaves, affecting photosynthesis and potentially killing plants. Noise emissions affecting workers. Noise emissions temporarily or permanently damaging the hearing of fauna in the vicinity of the blast.	High	Operating procedures. Blasting conducted once per year, duration of a few seconds. PPE for workers.	Unlikely	Insignificant	Low
21	**Construction and operation of water pipeline.**	Leak/spill of saline water.	Death of vegetation through osmosis of saline water.	High	Design controls to monitor flow through pipeline, any loss will immediately trigger an alarm in the process control unit. Close isolation valves. Cease pumping water. Inspect water pipeline and repair damaged section.	Unlikely	Minor	Low
22	**Use of saline water for dust suppression**	Watering of native vegetation along roadsides.	Uptake of saline/brackish water and death of vegetation.	High	Use a dribble bar on the back of the water cart instead of a spray bar. Equipment maintenance. Operational procedures.	Unlikely	Minor	Low
23	**Fencing of the waste cells.**	Exclusion of fauna from potential habitat.	Forced translocation of fauna into other habitat and increased predation in new habitat. Potential for injury/death of Threatened/Priority fauna.	High	Fences to be removed following revegetation of cells.	Rare	Insignificant	Low
24	**Waste Laboratory.**	Minor spill of sample during testing of waste.	Radiation exposure of workers. Injury (e.g. chemical burn) to workers.	High	Building enclosed and contains fume hoods. PPE. Operational procedures for waste testing. Training of operators. Regular toolbox meetings.	Unlikely	Minor	Low
25	**Water retention ponds.**	Leak/crack in pond liners.	Release of contaminated water to underlying and surrounding soils and potentially damage vegetation associated with those soils.	High	Shallow monitoring bores. Low hydraulic conductivity means water will not move far from the spill site. Contain and clean-up the spill. Operational procedure for management of contaminated soils.	Unlikely	Insignificant	Low
26	**Naturally occurring events.**	Earthquakes (size 3)	Slight subsidence of cell, consolidates backfill and potential creates a void.	High	Post event inspection and records kept. Repair cap if needed. Subsidence monitoring.	Possible	Insignificant	Low
27	**Naturally occurring events.**	Cyclones/flood	Increased rainfall at the site, overflow of contaminated water ponds which may impact surrounding soils, cause widespread flooding of contaminated surface water and injure/kill biota. Cell fills with water and leachate generated and then overflows to surrounding environment.	High	Small quantities of water. 24 hour duration. Pumping out of ponds prior to cyclone. Roof canopy over open cell. Operational bunds around cells. Waste still in shipping containers. Waste disposal halted if cyclone expected.	Unlikely	Insignificant	Low

Risk Number	Environmental Aspect	Sources of Risk (Hazard)	Potential Environmental Impact (Worst case)	Pre–management risk	Management and Mitigation Measures	Post–management Risk		Residual risk
						Likelihood	Consequence	
28	**Aboriginal heritage.**	Destruction of aboriginal heritage site and/or cultural association. E.g. clearing native vegetation of significance, excavating land of significance, and storing waste on significant land.	Degradation of heritage value of the local area.	High	Aboriginal heritage pre-construction survey. Operational procedure for encountering aboriginal cultural material. Contact WA Police if skeletal material is uncovered.	Rare	Minor	Low
29	**Malleefowl mound.**	Construction of pipeline. Construction of road and plant.	Removal or damage to an active nesting mound.	High	Malleefowl survey pre-construction to identify new active mounds. Re-design pipeline route to avoid mound. Report disturbance to an active mound to DPAW and DotE.	Rare	Insignificant	Low
30	**Landform.**	Change in landform by placing domed caps up to 5m higher than the landscape.	Ponding around the toe of the landform. Erosion.	Moderate	Engineering design. Engineering design as constructed plans demonstrated cell backfilling/capping competently constructed. Long term erosion modelling. Revegetation present.	Unlikely	Insignificant	Low
31	**Transport of chemical and radioactive waste.**	Leak of liquid material (e.g. NORM and/or hydrocarbons) from shipping container.	Humans within the vicinity of the leaked material may receive a one off higher dose of radiation above background levels or chemical exposure.	Low	Waste packaged as appropriate to level of hazard. Trucks travel on sealed roads or controlled site access roads. Transport contractor on Tellus Register of Approved Transporters. DG rated trucks (e.g. carry clean-up equipment and drivers are trained to manage a leak). Audits of transport contractor's procedural controls. Truck parked up. Source of the leak is investigated and contained. Clean-up undertaken. Emergency Response and Management Plan.	Rare	Insignificant	Low
32	**Subsurface waste disposal**	Permanent isolation of waste over geological time.	Gamma radiation exposure at the surface on surrounding humans, soils, flora and vegetation and fauna.	Low	Safety Case and Safety Assessment. Baseline radiation survey. Engineering design - depth of burial in shaft and materials used in construction. Institutional control period.	Rare	Insignificant	Low
33	**Creation of mine pits**	Alteration to surface water runoff.	Changes hydrology (quality and quantity) and effects on downstream vegetation.	Low	High infiltration rate (500mm/day). High evaporation rate (2400mm/year). Vegetation likely to be dependent only on landing rainfall, not runoff. Vegetation adapted to low rainfall (<250mm/year).	Rare	Insignificant	Low
34	**Kaolin Process Plant**	Operation of the plant. Incorrect disposal of wastes (e.g. waste oil, oily rags)	Dust emissions affecting workers. Dust emissions settling on plant leaves, affecting photosynthesis and potentially killing	Low	Wet process. Building enclosed and contains dust extraction system (e.g. baghouse).	Rare	Insignificant	Low

Risk Number	Environmental Aspect	Sources of Risk (Hazard)	Potential Environmental Impact (Worst case)	Pre–management risk	Management and Mitigation Measures	Post–management Risk Likelihood	Post–management Risk Consequence	Residual risk
			plants. Noise emissions affecting workers. Noise emissions temporarily or permanently damaging the hearing of fauna in the vicinity. Hydrocarbon contamination of soils.		PPE. Noise levels monitored to comply with OHS Regulations. Operational procedures. Training of operators. Regular toolbox meetings. Oily waste disposed offsite.			
35	**Water abstraction from Carina pit**	Create a cone of depression within the Carina pit.	Change to groundwater aquifer (quality and quantity) at Carina pit	Low	Measurements of quality and drawdown of the water within the pit. Monitor abstraction volumes. Groundwater modelling to confirm cone of depression.	Unlikely	Insignificant	Low
36	**Failure of waste cell containment, cell instability/collapse during operations.**	Placement of liquid/gas waste packages into the cell. Over time voids are created in the cell. Generation of leachate as water infiltrates the cell. Failure of cell wall and/or cap. Faulty design. Faulty construction - waste package placement/backfill. Differential settlement. Earthquake. Intentional disturbance to the cell to retrieve radioactive material.	Degradation of groundwater quality.	Low	Seepage rate low. High evaporation rate. High evapotranspiration rates. High energy hydrological environment. Large unsaturated zone and storage capacity beneath each cell. Backfill material is unsaturated and can store water. No aquifer within weathered granite. No groundwater dependent vegetation, Threatened species or TECs/PECs. Engineering design/site selection based on international best practice for near surface geological repositories. Operational procedures for appropriate wastes and waste acceptance criteria. Training of operators. Subsidence monitoring of cap. Groundwater monitoring.	Rare	Insignificant	Low
37	**Waste package comprising a sealed source arrives with an activity concentration >3,700 Bq/g arrives at the site.**	The waste package exceeds the waste acceptance criteria and will not be <370 Bq/g at the end of the institutional control period (300 years).	Potential exposure of workers during handling of the waste package.	Low	Disposal permit issued. Proforma issued. Inspection and measurement of all sealed sources on arrival at site. Dose meters attached to workers.	Rare	Minor	Low
38	**Waste package comprising a sealed source arrives with a half-life greater than 30 years and is placed in the cell.**	The waste package exceeds the waste acceptance criteria and will not be <370 Bq/g at the end of the institutional control period (300 years).	Acute or chronic radiation exposure possible to the public utilising the land in 300 years' time.	Low	Disposal permit issued. Proforma issued. Inspection and measurement of all sealed sources on arrival at site. Depth of burial. Operational procedures.	Rare	Insignificant	Low
39	**Erection of buildings**	Kaolin processing plant will be the tallest building. Tourists will not be allowed to enter the mine site.	Change to visual amenity of people conducting nature based tourism activities in Mount Manning Range Nature Reserve, Mount Manning - Helena - Aurora Ranges Conservation Park.	Low	Normal travel routes on existing roads will not be affected by Tellus operations. 10 km distance from nearest existing reserve (Mount Manning Range) and unlikely the kaolin processing plant	Rare	Insignificant	Low

Risk Number	Environmental Aspect	Sources of Risk (Hazard)	Potential Environmental Impact (Worst case)	Pre–management risk	Management and Mitigation Measures	Post–management Risk		Residual risk
						Likelihood	Consequence	
			Interference with scientific studies in existing and proposed reserve system.		will be visible from this distance. There is not expected to be an encounter with scientists within ex-Jaurdi Pastoral Lease, given operations will be outside of the Lease area.			
40	**Surface water**	Leak or spill from a waste package.	Degradation of water quality.	Low	Minimal volumes of surface water that will be present at the time of a spill/leak (i.e. surface water flows only in extreme rainfall events). Various barriers around, and integrity of, the waste package itself. Factors that affect leachability of solid waste. Unloading of waste packages within enclosed warehouses with bunded concrete floors. Distance to nearest receptor (48 km away).	Rare	Insignificant	Low

4.3 Risk evaluation

The outcome of the risk assessment included the identification of 40 credible risks, of these 28 are planned (i.e. elements of Tellus activities that will interact with the environment) and 12 are unplanned (unexpected interactions with the environment). With the implementation of management and mitigation measures, the division of the residual risks for the project were:

- 7 – High residual risks.
- 5 – Moderate residual risks.
- 28 – Low residual risks.

The residual risks were evaluated using the Tellus risk criteria (Table 4–2).

Table 4–2 Risk criteria

	Extreme	**Unacceptable** further management review required to reduce risk.
	High	**Tolerable** if management determine and accepts risk has been reduced to as low as reasonably practicable.
	Moderate	**Acceptable** with management review for continuous improvement.
	Low	**Acceptable** no further management required.

As stated in *HB 203:2012 Managing Environment–Related Risk:*

'Tolerable' refers to the willingness to live with a risk to secure benefits, on the understanding that it is being properly controlled. 'Tolerability' does not mean 'acceptability'. Tolerating a risk does not mean that it is regarded as negligible, or something that can be ignored, but rather as something that should be kept under review such that if and when feasible and appropriate it can be reduced still further.

'Acceptable' relates to risks that do not need further treatment at this stage. The expression acceptable level of risk refers to the level at which it is decided that further action is not worthwhile, e.g. additional effort will not result in significant reductions in risk levels.

5 RISK TREATMENT

The purpose of risk treatment is to achieve objectives by managing uncertainty as effectively as possible. As no 'Extreme' risks have been identified, and the residual risk levels for all hazards have been evaluated as **Tolerable** or **Acceptable** it is considered no further treatment of risks is required at this stage.

In future environmental risk assessments, if the risk profile is elevated to 'Extreme' risk treatment will be undertaken by Tellus.

6 MONITORING AND REVIEW

Monitoring and review of the environmental risks associated with the project will be conducted using the following methods:

1. Monitor the environment itself – monitoring requirements specified in the PER and the Environmental Management System (EMS) will be undertaken. The outcomes of the monitoring, and any new risks identified will be outlined in future risk assessments.
2. Monitor and respond to losses and incidents – incidents which occur during the construction and operations phase, that potentially lead to environmental harm, will be documented and reviewed.
3. Monitor the implementation of the Emergency Response and Management Plan and where possible continuously improve the procedures outlined in the plan.
4. Use internal and external audits in accordance with EMS requirements.

7 REFERENCES

SAI Global, 2009, *AS/NZS ISO 31000:2009 Risk Management–Principles and Guidelines,* available at: http://infostore.saiglobal.com/store/details.aspx?ProductID=1378670

SAI Global, 2012, *HB 203:2012 Managing Environment–Related Risk,* available at: http://infostore.saiglobal.com/store/details.aspx?ProductID=1516912

APPENDIX

A.1 Risk matrix

Consequence descriptors

Consequences	Insignificant	Minor	Moderate	Major	Catastrophic
Safety and Health	Near miss / hazard.	First aid treatment required.	Medical treatment required, no lost time.	Lost time injury(s) (LTIs).	Potential fatality / multiple LTIs.
Regulatory	No breach of works approval/licence/approval condition	Breach of one works approval/licence/approval condition.	Injunction under the EPBC Act. Infringement notice issued under the EP Act. Breach of several licence conditions/ministerial statement conditions/proponent commitment.	Directed environmental audits under the EPBC Act. Environmental Field Notice, Caution Notice, Management Letter or Non Compliance Notice issued under the EP Act.	Civil and criminal penalties under the EPBC Act and EP Act. Suspension or revocation of works approval/licence.
Pollution	No noise emitted from operation. Minor spill cleaned up in hours to days. No residual contamination following clean-up, no effect on watercourses, water bodies or aquifers.	Low level of noise emitted but not received at noise sensitive premise. Contamination of a watercourse, water body and/or aquifer, cleaned up in days to months.	Moderate level of noise emitted but expected to be below Noise Regulation limits at noise sensitive premises. Massive contamination of a watercourse, water body or aquifer, with clean-up over months to years.	High level of noise emitted and expected to be above the Noise Regulation limits at noise sensitive premises. Massive irreverable contamination of a watercourse, water body or aquifer.	Noise emitted causes temporary or permanent hearing loss. Toxic release off site with massive detrimental effect. Massive pollution with significant remedial work required. Global media interest.
Flora / Fauna	Damage to flora. Death or Injury of individual fauna.	Damage to priority flora. Death or injury of individual priority fauna. Destruction of fauna habitat.	Damage to Threatened/declared rare flora. Destruction of priority flora species. Death of priority fauna species. Death or injury of individual Threatened or Migratory fauna. Damage of critical fauna habitat.	Damage to critically endangered flora. Destruction of Threatened/declared rare flora species. Destruction of critical fauna habitat. Death or injury of individual critically endangered fauna.	Extinction of fauna species. Extinction of flora species. Destruction of critical habitat.

Consequences	**Insignificant**	**Minor**	**Moderate**	**Major**	**Catastrophic**
Socio / Political	Localised temporary impact	Localised, short term impact, closure of access roads, temporary loss of amenity.	Localised, long term impact but manageable. Evacuation of site and closure of neighbouring operations.	Localised, long term impact with unmanageable outcomes. Evacuation of site, and people within 200 km of the site, closure of major highway.	Long term regional or national impact, permanent isolation from the site and region.
Heritage	Damage or disturbance occurring near to (but not at) an Aboriginal Site. Access to an Aboriginal Site lost for up to two weeks.	Unauthorised access to or interference with an Aboriginal Site (e.g. movement of an artefact) without causing damage. Access to an Aboriginal Site lost for up to one month.	Minor damage to an Aboriginal Site or to an artefact at an Aboriginal Site. Access to Aboriginal Site lost for up to three months.	Major damage to an Aboriginal Site or to an artefact at an Aboriginal Site. Access to Aboriginal Site lost for up to six months.	Destruction of an Aboriginal Site or an artefact at an Aboriginal Site. Permanent loss of access to an Aboriginal Site.
Financial / Legal	<$50,000	$50,000 - 250,000	$250,000 - 400,000	$400,000 - 10M	>$10m

Likelihood descriptors

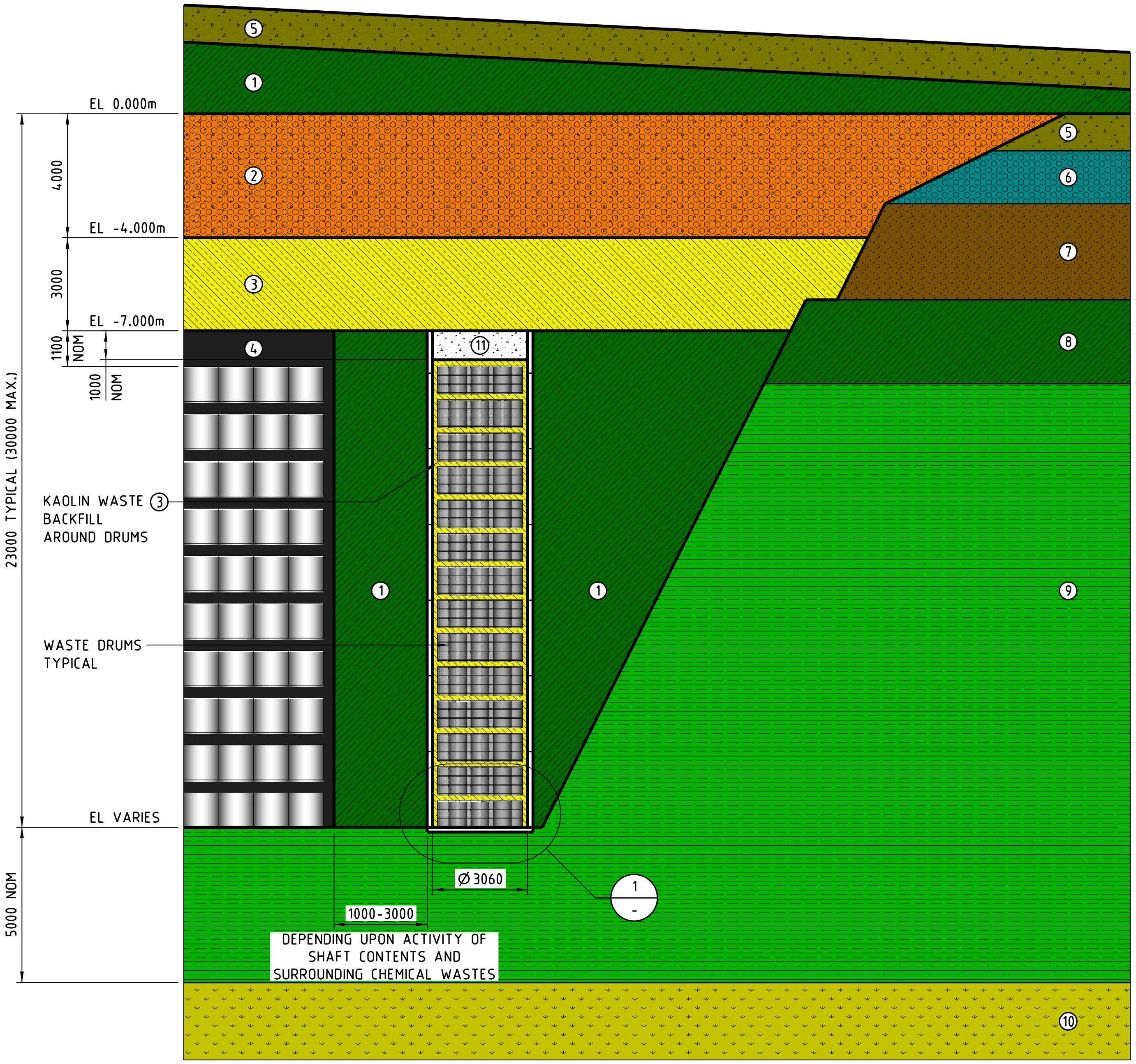
Rare	Unlikely	Possible	Likely	Almost Certain
5%	20%	50%	80%	95%
Highly unlikely to occur on this project	Given current practices and procedures, this incident is unlikely to occur on this project	Incident has occurred on a similar project	Incident is likely to occur on this project	Incident is very likely to occur on this project, possibly several times

Risk matrix				Consequence				
				Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
				1	**2**	**3**	**4**	**5**
Likelihood	**A**	Almost Certain	95%					
	B	Likely	80%					
	C	Possible	50%					
	D	Unlikely	20%					
	E	Rare	5%					

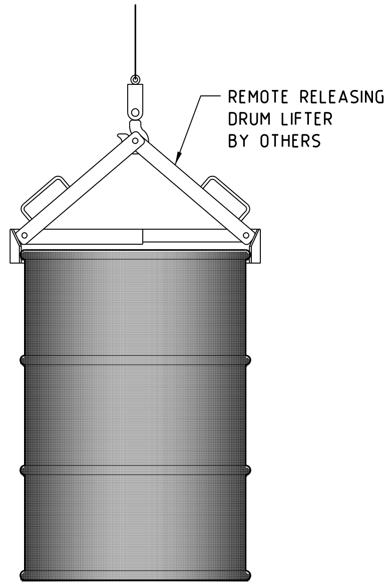
Risk criteria

	Extreme	**Unacceptable** further management review required to reduce risk.
	High	**Tolerable** if management determine and accepts risk has been reduced to as low as reasonably practicable.
	Moderate	**Acceptable** with management review for continuous improvement.
	Low	**Acceptable** no further management required.

A.3 Vertical shaft drawing



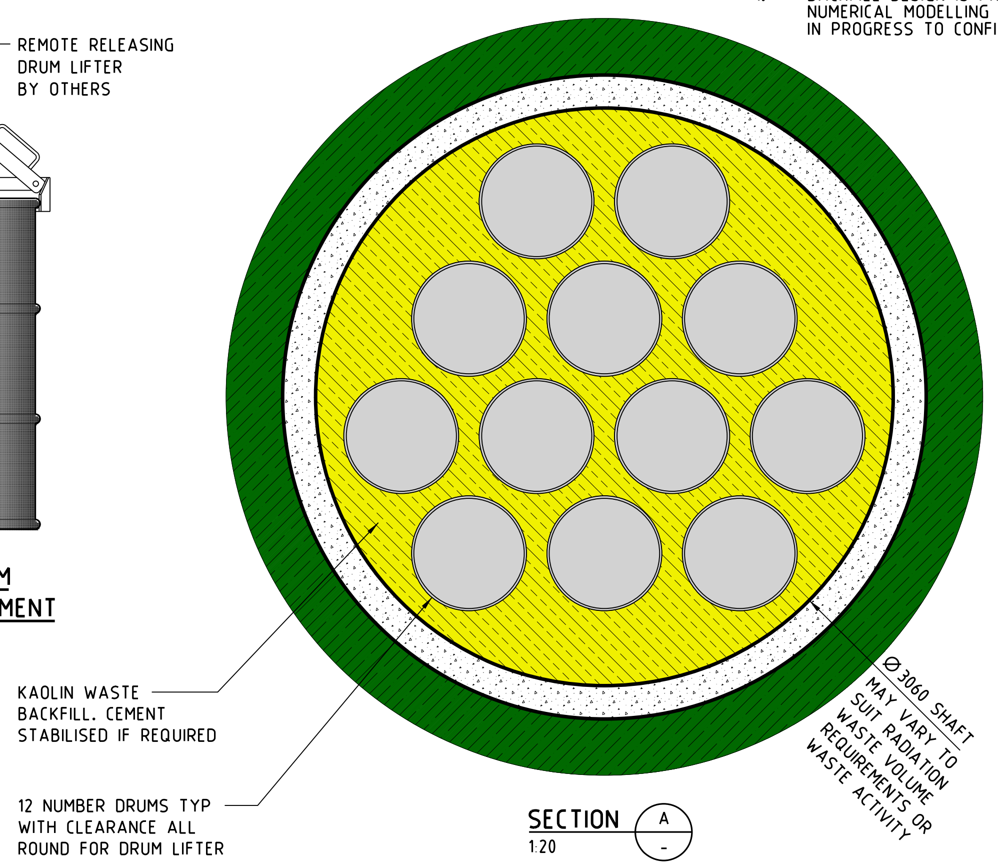
TYPICAL SECTION



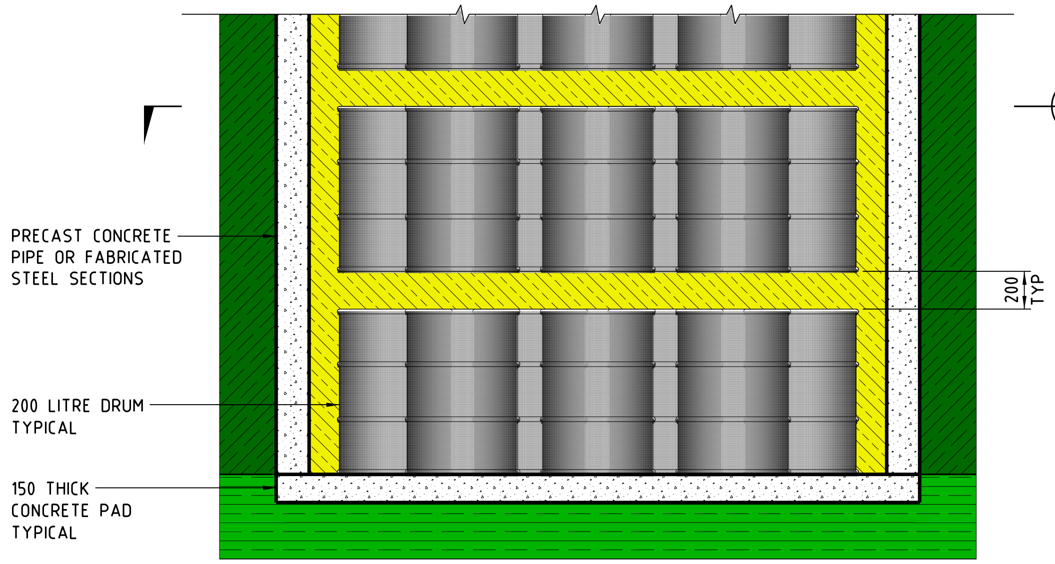
TYPICAL DRUM LIFTING ARRANGEMENT
SCALE 1:10

NOTES

1. BACKFILL DESIGN IS PRELIMINARY ONLY. NUMERICAL MODELLING CALCULATION IS IN PROGRESS TO CONFIRM DESIGN.



SECTION A/- 1:20



DETAIL 1/- 1:20

LAYER LEGEND - CELL AND SHAFT BACKFILL

1. MOTTLED CLAYS COMPACTED TO 95%MMDD
2. MIXED LATERITE AND SILCRETE AND CLAYEY SAND COMPACTED TO 95%MMDD, MAX. PARTICLE SIZE 40mm
3. KAOLIN WASTE COMPACTED TO 90%MMDD
4. WASTE SAND BACKFILLED AROUND DRUMS/BAGS COMPACTED TO 90%MMDD
11. CEMENT STABILISED COMPACTED KAOLINISED GRANITE

LAYER LEGEND - EXISTING GROUND

5. CLAYEY SAND
6. LATERITE
7. SILCRETE
8. MOTTLED CLAYS (IRON STAINED KAOLINISED GRANITE)
9. KAOLINISED GRANITE
10. UNWEATHERED GRANITE

LAYER LEGEND - SURFACE REHABILITATION

5. CLAYEY SAND

0.2 0.1 0 0.2 0.4 0.6 Metres
SCALE 1 : 10
0.4 0.2 0 0.4 0.8 1.2 Metres
SCALE 1 : 20
2 1 0 2 4 6 Metres
SCALE 1 : 100

INFORMATION ONLY
NOT FOR CONSTRUCTION

REV	BY	DATE	DESCRIPTION	CHKD	ENG
B	AL	27.11.15	FINAL REHABILITATION SURFACE ADDED	JL	
A	BK	02.09.15	ISSUED FOR INTERNAL AND CLIENT REVIEW	JL	

REF DRG No | TITLE

CLIENT: TELLUS

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	BY	DATE
DRAWN	B KLEMICK	02.09.15
CHKD		
DES ENG		
PROJ ENG		
CLIENT		

CLIENT DRG No.

TITLE
TELLUS SANDY RIDGE
PRE-FEASIBILITY STUDY
WASTE ISOLATION SHAFT IN CELL
BACKFILL GENERAL ARRANGEMENT

PROJECT No C5409 | A1 | SCALE 1:100 UNO | DRG No C5409-6310-CE-004 | REV B

27/11/2015 1:24:45 PM FILE: M:_Projects\C5409\Civil Earthworks\Active\C5409-6310-CE-004.dgn OWNER: adrian.lee