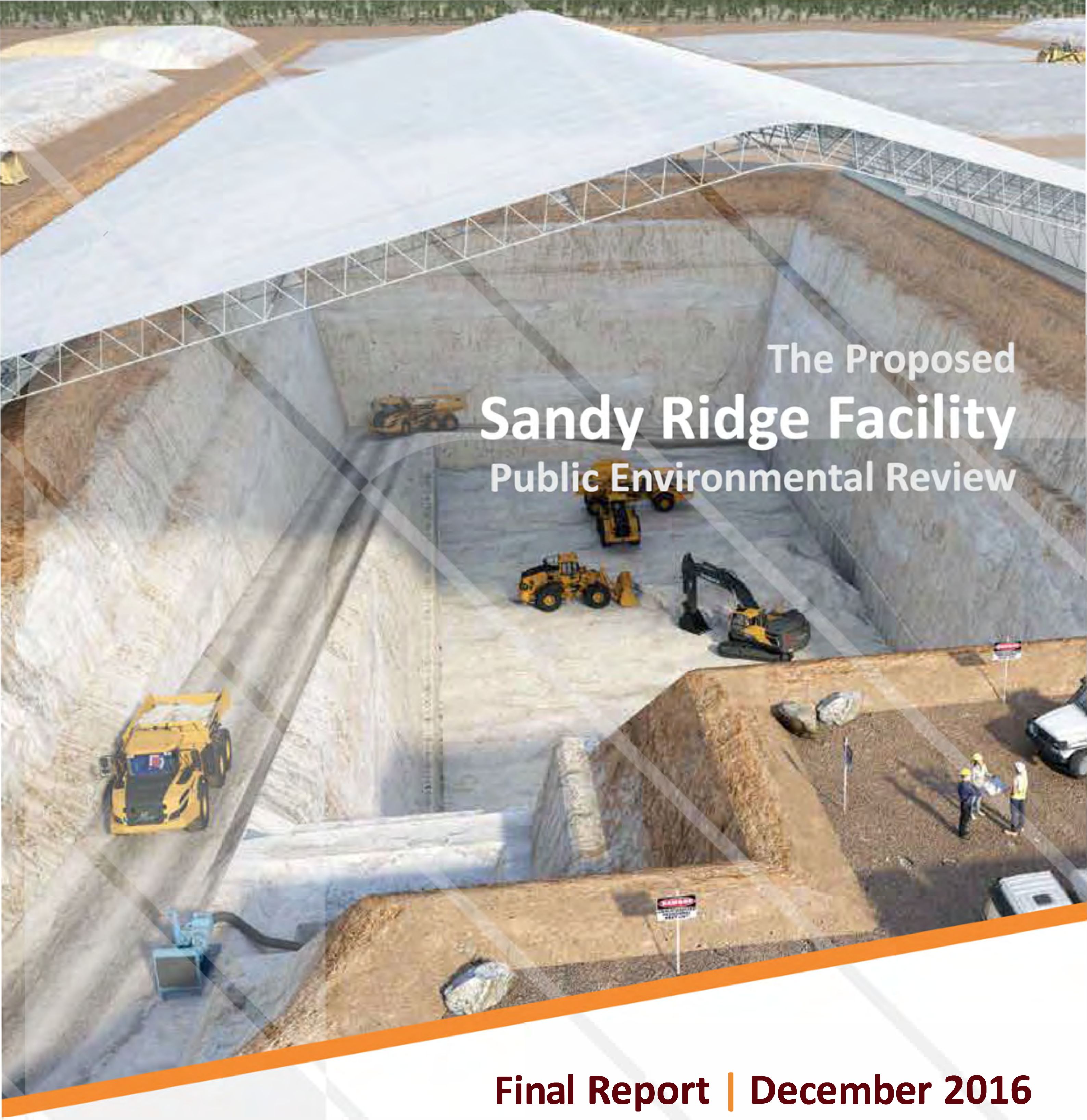

The Proposed Sandy Ridge Facility Public Environmental Review

Final Report | December 2016

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THE PROPOSED SANDY RIDGE FACILITY PUBLIC ENVIRONMENTAL REVIEW

Final Report | December 2016

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Major document contributors

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Terrestrial fauna survey	Terrestrial Ecosystems
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Review role	Team member	Origin
Engineering design of the proposed waste cells. Hazardous waste acceptance, storage, disposal and permanent isolation methods.	Mr Andy Baker	Eden Nuclear and Environmental Ltd United Kingdom

Document control

Rev	Issue date	Description	Originator	Checked	Approved
1	11/11/2016	PER for Public Review	Tellus Holdings Ltd		

INVITATION TO MAKE A SUBMISSION

The Environmental Protection Authority (EPA) invites people to make a submission on this proposal. The environmental impact assessment process is designed to be transparent and accountable and includes specific points for public involvement, including opportunities for public review of environmental review documents. In releasing this document for public comment, the EPA advises that no decisions have been made to allow this proposal to be implemented.

Tellus Holdings Ltd (Tellus) is seeking environmental approval to develop a dual use kaolin mine with the voids created by mining used to store and permanently isolate hazardous and intractable wastes. In accordance with the *Environmental Protection Act 1986*, a Public Environmental Review (PER) document has been prepared that describes this proposal and its likely effects on the environment. The PER document is available for a public review period of **12** weeks from **12th December 2016,** closing on **7th March 2017.**

Comments from government agencies and the public will assist the EPA to prepare an assessment report in which it will make recommendations to government.

Where to get copies of this document

Printed and CD copies of this document may be obtained from Tellus' Office located at Level 34, Exchange Tower, 2 The Esplanade, Perth, Western Australia, 08 8257 3395. Hard copies of the document cost $10 (including postage); CD's will be provided free of charge.

The PER may also be accessed through the proponent's website at www.tellusholdings.com

Why write a submission?

A submission is a way to provide information, express your opinion and put forward your suggested course of action – including any alternative approaches. It is useful if you indicate any suggestions you have to improve the proposal.

All submissions received by the EPA will be acknowledged, with electronic submissions being acknowledged electronically. The proponent will be required to provide adequate responses to points raised in submissions. In preparing its assessment report for the Minister for Environment, the EPA will consider the information in submissions, the proponent's responses and other relevant information. Submissions will be treated as public documents unless provided and received in confidence, subject to the requirements of the *Freedom of Information Act 1992*, and may be quoted in full or in part in the EPA's report.

Why not join a group?

If you prefer not to write your own comments, it may be worthwhile joining a group or groups interested in making a submission on similar issues. Joint submissions may help to reduce the workload for an individual or group, as well as increase the pool of ideas and information. If you form a small group (up to 10 people), please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

Developing a submission

You may agree or disagree with or comment on the general issues or specific elements discussed in the PER document. It helps if you give reasons for your conclusions, supported by relevant data. You may make an important contribution by suggesting ways to make the proposal more environmentally acceptable.

When making comments on specific elements in the PER document:

- clearly state your point of view;
- indicate the source of your information or argument if this is applicable; and
- suggest recommendations, safeguards or alternatives.

Points to keep in mind

By keeping the following points in mind, you will make it easier for your submission to be analysed:

- attempt to list points so that issues raised are clear. A summary of your submission is helpful;
- refer each point to the appropriate section, chapter or recommendation in the PER document;
- if you discuss different sections of the PER document, keep them distinct and separate, so there is no confusion as to which section you are considering; and
- attach any factual information you may wish to provide and give details of the source. Make sure your information is accurate.

Remember to include:

- your name;
- address;
- date; and
- whether you want your submission to be confidential.

The closing date for submissions is: **7th March 2017**

The EPA prefers submissions to be made at: https://consultation.epa.wa.gov.au.

Alternatively, submissions can be:

- posted to: Chairman, Environmental Protection Authority, Locked Bag 10, East Perth, Western Australia 6892; or
- delivered to the Environmental Protection Authority, Level 8, The Atrium, 168 St Georges Terrace, Perth.

If you have any questions on how to make a submission, please ring the Office of the Environmental Protection Authority on (08) 6145 0800.

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Disclaimer

This Public Environmental Review (PER) has been prepared for submission to the Western Australian Environmental Protection Authority for the purpose of the Minister for Environment making a determination regarding whether to approve Tellus Holding Limited's Proposal under the Western Australian Environmental Protection Act 1986. This PER has been developed for this purpose only, and no one other than the Environmental Protection Authority or the Minister should rely on the information contained in this PER to make any decision.

In preparing the Public Environmental Review (PER) Tellus has relied on information provided by specialists' consultants, government agencies and other third parties available during the preparation period. Tellus has not fully verified the accuracy or completeness except where expressly acknowledged in the PER.

The PER has been prepared for information purposes only; and, to the full extent permitted by law, Tellus, in respect of all persons other than the Environmental Protection Authority or the Minister, makes no representation and gives no warranty or undertaking, expressed or implied, in respect of the information contained in the PER and does not accept responsibility and is not liable for any loss or liability whatsoever arising as a result of any person acting or refraining from acting on any information contained in the PER.

Copyright

CERTIFICATION

Submission of Public Environmental Review

Prepared under Part IV Divisions 1 and 2 of the *Environmental Protection Act 1986*, Administrative Procedures 2012, Section 133 of the *Environment Protection Biodiversity Conservation Act 1999* and Schedule 4 to the EPBC Regulations.

Public Environmental Review submitted by:

Name:
Tellus Holdings Ltd

Qualifications of certifier:
Mr Richard Phillips
BEnvSci (Hons)
DipAppSci (Landscape Engineering)

Address:
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In respect of:
The Sandy Ridge Facility

Applicant name:
Tellus Holdings Ltd

Applicant address:
Suite 2
Level 10, 151 Castlereagh Street
Sydney, NSW 2000

Land to which the proposal seeks approval:
The proposed Sandy Ridge exploration licence (E16/440)

Environment assessment:
A Public Environmental Review is attached

Certificate
I certify that I have prepared the contents of this document and to the best of my knowledge:

- It is in accordance with the requirements of the *Environmental Protection Act* and associated regulations.
- It contains all available information that is relevant to the Environmental Assessment of the development to which it relates.
- The information contained in the document is neither false no misleading.

Certifier signature

ABBREVIATIONS

ABS	Australian Bureau of Statistics
ADT	Articulated Dump Truck
AMAD	Measurement of Aerosol Size Distribution
ANSTO	Australian Nuclear Science and Technology Organisation
ARI	Average Recurrence Interval
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
ASNO	Australian Safeguards and Non-proliferation Office
AWS	Automated Weather Station
BGL	Below Ground Level
BIF	Banded Iron Formation
BoM	Bureau of Meteorology
Bq/g	Becquerels per gram
Bq/kg	Becquerels per kilogram
Bq/m^3	Becquerels per cubic metre
°C	degrees Celsius
CAMBA	China–Australia Migratory Bird Agreement
CEMP	Construction Environmental Management Plan
CPPNM	Convention on the Physical Protection of Nuclear Material
CRM	Continental Resource Management Pty Ltd
Cth	Commonwealth
DAA	Department of Aboriginal Affairs
dB(A)	Decibels (A-weighted)
DEC	Department of Environment and Conservation
DER	Department of Environment Regulation

DMA	Decision Making Authority
DMP	Department of Mines and Petroleum
DoEE	Department of the Environment and Energy (Commonwealth)
DPAW	Department of Parks and Wildlife
DPC	Department of the Premier and Cabinet
DSEWPAC	Department of Sustainability, Environment, Water, Population and Communities
EAG	Environmental Assessment Guideline
ELAW	Environmental Law Alliance Worldwide
EMS	Environmental Management System
ENRESA	Empresa Nacional de Residuos Radiactivos
EPA	Environmental Protection Authority
EP Act	*Environmental Protection Act 1986*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EPBC Regulations	Environment Protection and Biodiversity Conservation Regulations 2000
ERICA	Environmental Risk from Ionising Contaminants Assessment
ESD	Environmental Scoping Document
FEL	front end loading
FIFO	fly-in–fly-out
FNA	File Notation Area
GPS	Global Positioning System
ha	hectare
HDPE	high-density polyethylene
HEU	High enriched uranium
HLW	High level radioactive waste
IAEA	International Atomic Energy Agency

IBRA	Interim Biogeographic Regionalisation of Australia
ICP	institutional control period
ICRP	International Commission on Radiological Protection
ILW	intermediate level waste
IMO	International Maritime Organisation
ISWA	International Solid Waste Association
IWDF	Intractable Waste Disposal Facility
JAMBA	Japan–Australia Migratory Bird Agreement
JORC	Joint Ore Reserves Committee
kg	kilogram
km	kilometre
kPa	kilopascals
LLA	*Land Administration Act 1997* (WA)
LEU	low enriched uranium
LLW	low level radioactive waste
LPG	Liquefied Petroleum Gas
m	metre
M	million
mAHD	elevation in metres
mm	millimetre
mm/year	millimetres per year
m/s	metres per second
m^3/s	cubic metres per second
MCP	Mine Closure Plan
MNES	Matters of National Environmental Significance
mSv	Millisieverts

Mt	million tonnes
NEA	Nuclear Energy Agency
NEPC	National Environment Protection Council
NEPM	National Environment Protection (Movement of Controlled Waste between States and Territories) Measure 1998
NHMRC	National Health and Medical Research Council
NORM	Naturally Occurring Radioactive Material
NPT	Non-Proliferation Treaty
NT	Northern Territory
NWP	National Waste Policy
OEMP	Operational Environmental Management Plan
OEPA	Office of the Environmental Protection Authority
PEC	Priority Ecological Community
PER	Public Environmental Review
PPE	personal protective equipment
RESRAD	A computer model designed to estimate radiation doses and risks from Residual Radioactive Materials
ROKAMBA	Republic of Korea–Australia Migratory Bird Agreement
ROM	run of mine
RnDP	radon decay product
SPL	spent pot liner
t	tonnes
TDS	total dissolved solids
TEC	Threatened Ecological Community
TETS	Tellus electronic tracking system
TLD	Thermoluminescent Dosimeter
tpa	tonnes per annum

µm	microns
UNEP	United Nations Environment Programme
VLLW	very low level waste
VSLW	very short lived waste
WA	Western Australia
WC Act	*Wildlife Conservation Act 1950*
WFDCP	Waste Facility Decommissioning and Closure Plan
WNA	World Nuclear Association
XRF	X–ray fluorescence

GLOSSARY

Absorbed dose	Quantity of energy imparted by ionizing radiation to unit mass of matter such as tissue. Unit gray, symbol Gy. 1 Gy = 1 joule per kilogram.
Activity	Attribute of an amount of a radionuclide. Describes the rate at which transformations occur in it. Unit becquerel, symbol Bq. 1 Bq = 1 transformation per second.
Anthropogenic	As an adjective - caused by humans. Anthropogenic radiation is radiation caused by human activity.
Aquifer	An underground layer of permeable rock, sediment or soil that yields water.
Becquerel (Bq)	See activity
Cell	An excavation or cut made beneath the ground for the purpose of encapsulating waste.
Chemical waste	See definition for 'controlled waste'.
Clean fill	Material that would have no harmful effects on the environment and which consists of rocks or soil arising from the excavation of undisturbed material.
Consequence	Includes cascade effects and impacts on the organisation'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).
Controlled waste	Any matter that is: (a) within the definition of waste in the National Environment Protection (Movement of Controlled Waste between States and Territories) Measure 1998 (NEPM) for the Movement of Controlled Waste between States and Territories (b) listed in Schedule 1 of the Environmental Protection (Controlled Waste) Regulations 2004.
Customer – kaolin	The buyer of Tellus' kaolin minerals.
Customer – waste	The owner of the waste. This may include a Waste Management Contractor company.

Proposed development envelope	Maximum area within which the disturbance footprint would be located.
Disposal/Permanent Isolation	Final stage in the management of the waste stream.
Dose	General term for quantity of ionizing radiation. See absorbed dose, equivalent dose, effective dose and collective effective dose. Frequently used for effective dose.
Dyke	Igneous rock that is often orientated vertically or steeply inclined to the bedding of pre-existing intruded rocks.
Ecological linkage	A series of (both contiguous and non-contiguous) patches of native vegetation which, by virtue of their proximity to each other, act as stepping stones of habitat which facilitate the maintenance of ecological processes and the movement of organisms within, and across, a landscape.
Effective dose	The quantity obtained by multiplying the equivalent dose to various tissues and organs by a weighting factor appropriate to each and summing the products. Unit sievert, symbol Sv. Frequently abbreviated to dose.
Electromagnetic radiation	Radiation that can be considered as a wave of electric and magnetic energy travelling through a vacuum or a material. Examples are gamma rays, x-rays, ultraviolet radiation, light, infrared radiation and radiofrequency radiation.
Encapsulation	The process of enclosing a waste within a secure container such as to render it acceptable for long-term permanent isolation.
Environmental aspect	Element of an organisation'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 organisation's activities, products or services.
Evaporation	Process of a substance in a liquid state changing to a gaseous state due to an increase in temperature and/or pressure.
Evapotranspiration	Process by which water is transferred from the land to the atmosphere by evaporation from the soil and other surfaces and by transpiration from plants.
Facility – Sandy Ridge	The Proposal is to develop a dual revenue business comprising an open cut kaolin mine that would produce up to 290,000 tonnes per annum (tpa) of ore, and up to 40,000 tpa of mostly ceramics for the Asian export market from an onsite

	kaolin processing plant, and would use the voids resulting from mining for the secure storage, recovery of valuable materials and permanent isolation of up to 100,000 tpa of hazardous and intractable waste using a best practice safety case.
Flux	A vector quantity, describing the magnitude and direction of the flow of a substance or property.
Half-life	The time taken for the activity of a radionuclide to lose half its value by decay. Symbol t½.
Hazard	Source of potential harm.
Hazardous waste	Component of the waste stream which by its characteristics poses a threat or risk to public health, safety or the environment (includes substances which are toxic, infectious, mutagenic, carcinogenic, teratogenic, explosive, flammable, corrosive, oxidising and radioactive).
High level waste	Has high levels of activity that generates significant quantities of heat by radioactive decay that needs to be considered in the design of a facility.
Hydraulic conductivity	The volume of liquid that flows through a unit area of porous medium for a unit hydraulic gradient normal to that area.
Hydrogeology	The study of subsurface water, including its physical and chemical properties, geological environment, its role in geologic processes, natural movement, recovery, contamination and utilisation.
Hydrology	The study of the waters of the Earth.
Indurated	Hardening of rocks by heat or baking; also, the hardening of sediments through cementation or compaction, or both, without the introduction of heat.
Infiltration	To pass into or through (a substance) by filtering or permeating.
Institutional control period	Following closure of the disposal facility, public access to, or alternative use of, the site shall be restricted for a predetermined period of time. See proposal description and/or National Health and Medical Research Council (NHMRC) 1992.
Intermediate level waste	Contains increased quantities of long-lived radionuclides and needs an increase in the containment and isolation barriers compared to low level radioactive waste. Intermediate level waste needs no provision for heat dissipation during storage

	and disposal. Long-lived radionuclides such as alpha emitters would not decay to a level of activity during the time for which institutional controls can be relied upon.
Intractable waste	Waste which is a management problem by virtue of its toxicity or chemical or physical characteristics, which makes it difficult to dispose of or treat safely, and is not suitable for disposal in Class I, II, III and IV landfill facilities.
Kaolinite	Kaolinite is a clay mineral, and part of the group of industrial minerals with the chemical composition $Al_2Si_2O_5(OH)_4$. Kaolinite is also known as kaolin or China clay. Kaolinite has a low shrink–swell capacity, low permeability and a low cation exchange capacity, which makes it suitable for waste encapsulation. It is a soft, earthy, usually white mineral. Kaolin is also widely used in the paper, ceramics, paint, plastic and fibreglass industries.
Leachability	The state of being leachable.
Leachable	Capable of being removed from a substance by a percolating liquid.
Leachate	Any liquid that in the course of passing through matter, extracts soluble or suspended solids, or any other component of the material through which it has passed.
Legacy waste	Waste physically accepted onto the premises of a waste diversion facility before 1 July 2012 that would otherwise have entered landfill.
Likelihood	The chance of something happening, whether defined, measured or determined objectively or subjectively, qualitatively or quantitatively, and described using general terms or mathematically.
Low level radioactive waste	May include short-lived radionuclides at higher levels of activity concentration, and also long-lived radionuclides, but only at relatively low levels of activity concentration. LLW covers a very wide range of radioactive waste, from waste that does not require any shielding for handling or transportation up to activity levels that require more robust containment and isolation periods of up to a few hundred years. LLW is generated in industry, hospitals and nuclear facilities and comprises contaminated laboratory items such as paper, clothing, plastic and glassware, soil, smoke detectors, medicinal and industrial materials.
Macropore	Any pore sufficiently wide enough to allow water to flow unimpeded by capillary action.

Mining spoil/overburden	The material that lies above an area that lends itself to economical exploitation, such as the rock, soil and ecosystem that lies above an ore body.
Natural uranium	Uranium as it occurs in nature, having an atomic weight of approximately 238, and containing minute quantities of Uranium-234 (about 0.7%), Uranium-235 and 99.3% Uranium-238.
Nuclear action	Means any of the following: (a) establishing or significantly modifying a nuclear installation (b) transporting spent nuclear fuel or radioactive waste products arising from reprocessing (c) establishing or significantly modifying a facility for storing radioactive waste products arising from reprocessing (d) mining or milling uranium ore (e) establishing or significantly modifying a large-scale disposal facility for radioactive waste (f) de-commissioning or rehabilitating any facility or area in which an activity described in paragraphs (a), (b), (c), (d) or (e) has been undertaken (g) any other action prescribed by the regulations.
Nuclear material	Depleted uranium, enriched uranium, low enriched uranium, highly enriched uranium, Uranium-233 or plutonium (defined in the PER body). Does not include natural uranium and thorium.
Nuclear waste	Nuclear waste means material: a) that is or contains a radioactive substance; and b) that: a. is a waste of a nuclear plant b. results from the testing, use or decommissioning of nuclear weapons.
Pegmatite	Intrusive felsic igneous rocks that form during the final stage of a magma's crystallisation. They are extreme because they contain exceptionally large crystals and they sometimes contain minerals that are rarely found in other types of rocks.
Permeability	The ease with which a porous medium can transmit water or other fluids.
Phenocrysts	Mineral crystals in an igneous rock that stand out because of their large size.
Pit	An excavation or cut made at the surface of the ground for the purpose of extracting ore and which is open to the surface for the duration of the mine's life.

Plutonium	A radioactive element with atomic number 94 and symbol Pu.
Porosity	The ration, expressed as a percentage, of the volume of the pores or interstices of a substance, as a rock or rock stratum, to the total volume of the mass.
Priority species	Possibly threatened species that do not meet the survey criteria, or are otherwise data deficient, are added to the Priority Fauna or Priority Flora Lists under Priorities 1, 2 or 3. These three categories are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as threatened flora or fauna.
The Proposal	A project, plan, program, policy, operation, undertaking or development or change in land use, or amendment of any of the foregoing, but does not include a scheme.
Radiation	The process of emitting energy as waves or particles. The energy thus radiated. Frequently used for ionizing radiation except when it is necessary to avoid confusion with non-ionizing radiation
Radioactive	Possessing the property of radioactivity.
Radioactive substance	Any substance, whether natural or artificial, and whether in the form of a solid, a liquid, a gas, or a vapour, or any compound or mixture, including any article that has been manufactured or subjected to any artificial treatment or process, which consists of or contains more than the maximum prescribed concentration of any radioactive element, whether natural or artificial.
Radioactive waste	Useless material containing radionuclides. Categorised in according to activity (and other criteria such as half-life) as exempt, low level, intermediate level and high level waste.
Radionuclide	An unstable nuclide that emits ionizing radiation.
Register	Tellus’ register of Transport Contractors who are approved for transport of hazardous wastes to the Sandy Ridge site.
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.
Saline	Water that contains a significant concentration of dissolved salts (mainly sodium chloride).

Saprolite	A weathering product produced by chemical weathering of crystalline rock (e.g. granite).
Sensitive receptor	Can be a natural feature, such as a water source, a rare, threatened or endangered flora or fauna. It can also be a human feature such as a school or a hospital.
Sievert (Sv)	The SI unit of dose equivalent (the biological effect of ionizing radiation), equal to an effective dose of a joule of energy per kilogram of recipient mass.
Silcrete	An indurated duricrust (hard layer) formed when surface materials are cemented by precipitated silica.
Subsidence	The downward vertical movement of the surface.
Thorium (natural)	A radioactive element with atomic number 90 and symbol Th. Naturally occurring thorium consists only of the fertile isotope thorium 232.
Threatened species	A species listed as extinct in the wild, critically endangered, endangered or vulnerable under either the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) or the *Wildlife Conservation Act 1950* (WC Act).
Transport contractor	A commercial freight service company. The Transport Contractor includes the principal company, all vehicles and operators and independent subcontractors.
Type 1 inert waste	Non-hazardous, non-biodegradable (half-life greater than two years) wastes containing contaminant concentrations less than Class I landfill acceptance criteria but excluding paper and cardboard (paper and cardboard are biodegradable materials and are therefore considered as putrescible waste), and materials that require treatment to render them inert (e.g. peat, acid sulfate soils).
Type 1 special waste	Waste which includes asbestos and asbestos cement products.
Type 2 inert waste	Waste consisting of stable non-biodegradable organic materials such as tyres and plastics which require special management to reduce the potential for fires.
Type 2 special waste	Waste consisting of certain types of biomedical waste which are regarded as hazardous but which, with the use of specific management techniques, may be disposed of safely within specified classes of landfill.

Ultraviolet radiation	Electromagnetic radiation found between x-rays and light in the electromagnetic spectrum. Has subregions UVA, UVB, UVC
UV radiation	See ultraviolet radiation
Very low level waste	Does not need a high level of containment and isolation. Concentrations of longer-lived radionuclides in very low level waste are generally very limited. Typical waste in this class includes soil and rubble with low activity concentration levels. Substantial amounts of waste arise from the operation of medical, industrial or research facilities with activity concentration levels in the region of or slightly above the levels specified for the exemption of material from regulatory control. Other such waste, containing naturally occurring radionuclides, may originate from the mining or processing of ores and minerals.
Very short lived waste	Waste with a very short half-life. This is mainly hospital waste, containing very-short-lived radionuclides (i.e. with half-lives that are less than 100 days), used for diagnostic or therapeutic purposes. Because of their very short half-lives, this waste is stored temporarily, for a period ranging from several days to several months and long enough for their radioactivity to decay. It is then disposed of as conventional waste.
Vug	A small cavity in a rock or vein, often with a mineral lining of different composition from that of the surrounding rock.
Waste management	The control of waste from creation to disposal.
Wavelength	The distance between successive crests of an electromagnetic wave passing through a given material. Unit metre, symbol m.
X-ray	A discrete quantity of electromagnetic energy without mass or charge. Emitted by an x-ray machine.

EXECUTIVE SUMMARY

Introduction

Tellus Holdings Ltd (Tellus) propose to construct and operate an open-cut kaolin mine and storage facility (herein referred to as the 'Sandy Ridge Facility', 'Facility', the 'Proposal' and the 'Sandy Ridge Project'). If approved, the Sandy Ridge Facility would be located approximately 75 kilometres (km) north-east of Koolyanobbing, in the Shire of Coolgardie, within the Goldfields Region of Western Australia (WA).

There are two key aspects of the Proposal. The first involves mining kaolin primarily for export to Asia or the domestic ceramic clay market. The second involves storing hazardous, intractable and low level radioactive wastes (LLW) within the void spaces left from the mining operations.

A Public Environmental Review (PER) has been prepared to support the approval of the Proposal under Part IV of the *Environmental Protection Act 1986* (WA) (EP Act) and the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act). The PER has been prepared to address the requirements set out in the final Environmental Scoping Document (ESD) for the Proposal issued by the WA Office of the Environmental Protection Authority (OEPA) on 26 May 2016. The PER has also been prepared to address the requirements set out in Schedule 4 of the Environment Protection and Biodiversity Conservation Regulations 2000 (Cth) (EPBC Regulations).

The proponent

Tellus is the proponent for the Proposal. Tellus is an infrastructure development company in the business of creating economic, social and environmental value from waste, clay and salt resources. This dual revenue model involves mining the commodities kaolin clay and rock salt in thick dry remote beds which creates world's best practice geological repositories. The voids created by mining are then used to store equipment, archives or waste using a multi barrier system as part of an overall safety case.

Tellus plans to permanently isolate hazardous waste using environmentally sound management principles that protect the environment and human health. Tellus also supports the circular economy using long term storage by placing like-with-like materials for operational safety reasons and to create opportunities for the future recovery of valuable materials. Tellus' business model mirrors international solutions operating in the United Kingdom, Europe and North America. Tellus is developing the proposed Sandy Ridge Facility in WA and the proposed Chandler Facility in the Northern Territory (NT) which has been awarded Major Project Status by the NT Government.

Company details

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Suite 2, Level 10
151 Castlereagh Street
Sydney NSW 2000.
ABN 97 138 119 829

Key contact for the PER is:

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Email: info@tellusholdings.com
Office: +61 2 8257 3395

Further information regarding the proponent is provided on their website at the following address: www.tellusholdings.com.au

Alternatives, justification and benefits

Alternatives to the Proposal

A range of options and alternatives were investigated for the Proposal including an assessment of the 'do nothing' scenario. In-depth, detailed investigations were also undertaken into site selection. Further investigations were undertaken with respect to the site selection for the mining components, the approach to mining the kaolin, access to the proposed development envelope, transportation of the kaolin, water and power supply alternatives, alternatives to handling mining spoil, the design of the waste cells, the types of waste to be accepted, the criteria for accepting them and the handling and storage of wastes.

Justification for the Proposal

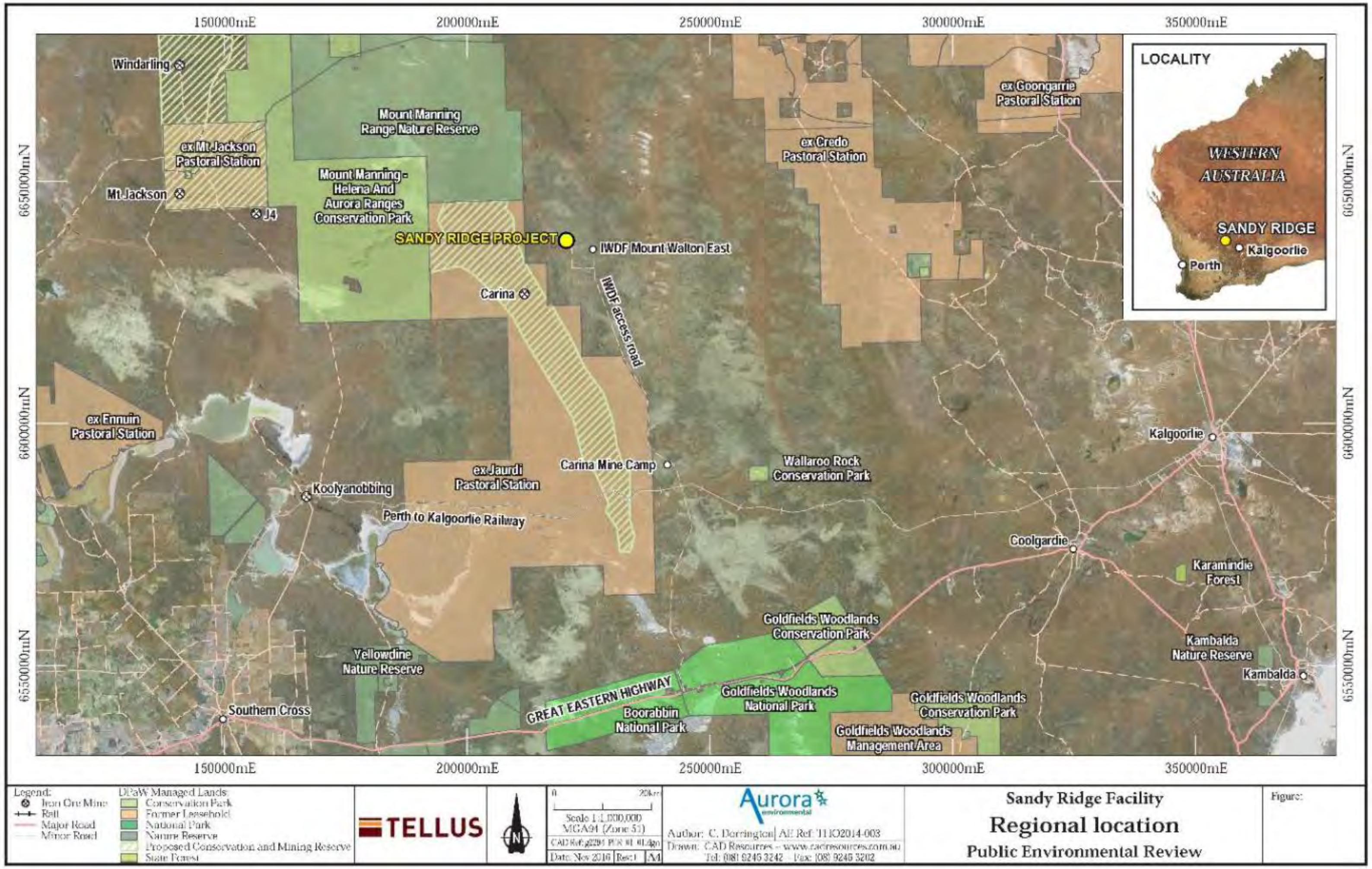
The viability of the proposed Sandy Ridge Facility would rely on implementing both aspects of the dual revenue Proposal:

- The kaolin business.
- The waste storage, recovery and isolation business (in an arid, near surface geological repository).

Kaolin business

Kaolin is found across Australia, with large deposits in WA, but significant production is now restricted to Victoria. Kaolin customers like Australian kaolin quality but are wary of Australian supply reliability. The Asia/Pacific region continues to have the largest kaolin market influence globally, underpinned by strong manufacturing demand and continued urban development amongst its emerging economies. These trends are expected to continue and consolidate Asia as the fastest growing region for kaolin demand over the next five years, hosting the top four growth users, China, India, Malaysia, and Thailand.

WA has a number of world class kaolin deposits. However, none of these to date, have been able to be developed on a commercial scale due to development and operating cost hurdles. In the case of Sandy Ridge, these economic disincentives are overcome because of the synergies of operating a dual revenue kaolin and waste repository, on the same site, and collecting two revenue streams.



Location of the proposed Sandy Ridge Facility

As a result, for the first time, WA would potentially have a viable kaolin mine, and storage facility which would generate additional regional investment, training and jobs, business opportunities, infrastructure, royalties and taxes for the State and improved overall product stewardship. The kaolin deposit at Sandy Ridge has been determined to be high grade and Australia is well positioned geographically for the distribution of the processed kaolin products into the Asian marketplace.

The dual revenue business model is attractive to investors as it generates a higher margin and is countercyclical. The benefit of this is that it produces a more predictable revenue stream. The customers who want to buy the kaolin and customers who want to use the storage space also like the dual revenue business as it gives them confidence that the operations would be reliable, cost effective, and sustainable and that Tellus would be around over the next 25 years.

Kaolin is used widely in the ceramic industry. It is also used in a number of other industries including the paper, paint, rubber, plastics, ink and insecticide industry.

Waste storage, recovery and isolation business

The problem

Australians are the second highest emitters of hazardous waste per capita due to our economy being driven largely by mining, oil and gas, and manufacturing. Approximately 10% of the waste Australian's produce is hazardous. That means approximately six million tonnes per year of known hazardous waste is produced and is growing at approximately 3% per annum. There is also approximately 900 million tonnes of reported legacy waste (hazardous and intractable waste generated historically) estimated to be temporarily stored in WA and across other Australian states and territories.

The solution

There is a need and regulatory obligation to provide for the safe and secure storage and permanent isolation of both hazardous and intractable waste. The solution put forward involves the isolation of such wastes in an arid near surface clay geological repository that safeguards human health and the environment from harm over geological time. This can be achieved by applying proven scientific and environmentally sound management principles.

A geological repository is an underground storage or disposal facility of hazardous and intractable waste that relies on both a natural geological barrier (e.g. a clay bed) and man-made engineered barriers that both form part of a multibarrier system as part of an overall safety case that is globally recognised for its permanent isolation capabilities.

The natural geological barrier isolates waste from the biosphere safely and permanently. Once the site is closed, it requires very little ongoing monitoring as the geological barrier is passively safe. The lifespan of containment is in the hundreds of thousands to millions of years. As a result, geological repositories that can permanently isolate materials are globally considered “best practice” for both hazardous, intractable and LLW.

At present, WA has one operational Class IV facility (Red Hill Waste Management Facility) and one campaign based operational Class V facility (IWDF). The IWDF facility is the only Class V facility in Australia and is also classed as an arid, near surface geological repository. However, the use of existing facilities, such as the IWDF facility, is limited due to the site being cost prohibitive and not well known. It is difficult for customers as the onus is on waste producers to demonstrate that they have exhausted all other potential options for handling the hazardous waste materials before they can be directed to the IWDF. The IWDF facility is also only open for a campaign style operation once every few years with the last operation being eight years ago in 2008.

The lack of cost effective and regular disposal operations at the IWDF facility means that potentially hazardous and intractable wastes are being stockpiled in undesirable circumstances around Australia or are shipped overseas at great expense to international facilities. Current management of hazardous and intractable waste, at unknown locations across Australia, may pose a significant human health and environmental risk due to their locations near sensitive environmental and social receptors. It is also possible that some wastes may be disposed of in an inappropriate or illegal manner.

The proposed Sandy Ridge Facility would operate within an environment not constrained by sensitivities such as communities as it is in a very remote area, groundwater, surface water or protected flora and fauna species or populations. In addition, the Facility would offer significantly lower gate charges than currently available at the IWDF facility. This would encourage the correct storage, recovery or disposal / permanent isolation of high risk hazardous and intractable wastes, eliminating a significant environmental residual risk to the community.

What hazardous and chemical wastes would Sandy Ridge take?

Hazardous and intractable chemical wastes that would and would not be accepted at the proposed Sandy Ridge Facility are listed in the table below.

Hazardous and intractable wastes (NEPM 75)	Accepted on site (surface storage)[2]	Accepted below ground in waste cells[2]
Hazardous and intractable wastes (NEPM 75) subject to meeting the characteristics criteria below (examples of acceptable wastes on next slides)	✓	✓
• Liquid and sludges	✓	×[1]
• Explosive wastes	✓	×[1]
• Flammable liquids or solids	✓	×[1]
• Self-combusting wastes or wastes that can generate a gas-air mixture which is toxic or explosive	✓	×[1]
• Highly corrosive or oxidizing	✓	×
• Gases	×	×
• **Clinical waste** *such as infectious hospital waste and body parts*	×	×
• **Municipal Solid waste** *such as putrescible household and commercial waste*	×	×
• Putrescible wastes *which rot such as household rubbish*	×	×
• Uncertified waste *which can not be identified or has not undergone characterisation testing*	×	×
• Reacts with the repository geology *such as dissolving it or producing a gas*	×	×

[1]*Normally excluded unless modified before disposal or during disposal so the operational or post closure safety of the waste cell and facility is not compromised.*
[2] ✓ = accepted, × = not accepted. ×[1]= normally excluded but possibly suitable[3]
[3] Classification of Radioactive Waste – ARPANSA RPS20

What types of low level radioactive wastes would be accepted at the proposed Sandy Ridge site?

Examples of low level radioactive wastes, such as medical isotopes, smoke detectors, sealed gauges as suitable for storage and disposal in accordance with the safety case, that would be accepted at the proposed Sandy Ridge site are shown in the table below.

Nuclear waste storage or disposal services would not be provided at the proposed Sandy Ridge Facility. The Sandy Ridge Project has not been nominated as a potential National Radioactive Waste Management Facility. No such nomination is planned and no such nomination would be accepted should it be made by any other party.

Table 1-1 NORM and LLR wastes accepted on site (surface) and below ground in waste cells

Radioactive wastes[2] (✓ = accepted, × = not accepted)	Accepted on site (surface storage)	Accepted below ground in waste cells
Naturally Occurring Radioactive Material (NORM) ***up to LLW activity levels*** *such as oil and gas industry scale*	✓	✓
Low level Waste (LLW) *such as smoke detectors, exit signs, industrial gauges and medical isotopes*	✓	✓
Intermediate level (ILW) and high level waste (ILW) *such as reprocessed spent nuclear fuel and components with high levels of radioactivity*	×	×
Nuclear waste *from power generation and defense use*	×	×

[1] *Classification of Radioactive Waste – ARPANSA RPS20*

Environmental suitability for a waste storage, recovery and isolation business

The following key site characteristics are of specific importance for establishing a dual use kaolin business and waste storage, recovery and isolation business (in an arid, near surface geological repository) at the site of the proposed Sandy Ridge Facility:

- Geologically stable – it has very low seismicity and no volcanic or tectonic activity.
- Natural geological barrier – the clay bed is approximately 70 million old and is laterally extensive, thick, flat, and has been stable for millions of years, and is capped by a natural impermeable rock layer. The in situ clay has very low permeability. When combined with the thickness and extent of the clay it would not transmit waste off-site, even if a solute (water) was present.
- Climate – Semi arid, therefore low erosion and water ingress risk.
- Groundwater and surface water – no regional aquifers present (confirmed through hydrogeological investigations), the site is not subject to flooding, it has low rainfall (averages just over 250 mm of rainfall per annum) and evaporation is greater than 2,000 mm per annum. This means that water would generally evaporate before infiltrating into the ground), and there are no defined surface watercourses or waterbodies in the proposed development envelope.
- Other features –
    - Very low rates of erosion.
    - Lack of commercial mineral deposits (other than kaolin).
    - It is located in an area with zero population (the closest non-permanent camp is approximately 52 km away).
    - There is no potential for medium to high value agriculture.

- The site has no special environmental or cultural features (confirmed through field surveys in consultation with stakeholder’s familiar with the area).

In addition to the above, the IWDF facility, Australia's only Class V waste disposal facility is located immediately to the east of the proposed development envelope as the locality has previously been recognised for its suitability for intractable wastes and has a 22-year safe operating history.

Benefits of the Proposal

The Proposal would result in significant, positive social and economic benefits to WA and to Australia, including:

- Providing a unique dual revenue business that commercialises an industrial bulk commodity (kaolin) and provides safe environmentally sound management solutions for difficult to manage hazardous waste resources.
- Future potential recovery of valuable materials (that are currently deemed waste).
- Long-term jobs and major investment and business opportunities in remote regional Australia.
- Diversification of the economy by an environmental infrastructure business with strong social, environmental and economic values.
- Royalties, taxes and levies over the 25 year term could support other parts of the economy.
- Employment and business opportunities that can support local and regional communities.

Indigenous training, employment and business opportunities would result from the Proposal

- Long project life of 26 years. The site can be expanded for generations (1 year build, 25 year operation plus possible rolling terms).
- Creation of approximately 90 jobs during the construction phase, and approximately 23 direct and 46 indirect (2x multiplier) during the operation phase.
- Benefits would apply to local indigenous communities where opportunities for training, employment and business opportunities during construction and operations exist.
- When operating, the Facility would also provide a reliable long-term utility service to other industries that produce waste materials within Australia.
- The Facility could attract new kaolin and waste recycling and recovery industries to WA, and support industrial development in WA, bringing attendant economic benefits.

Tellus has supported indigenous jobs (left) and local firms (right) during the development of the PER.

Legislative framework

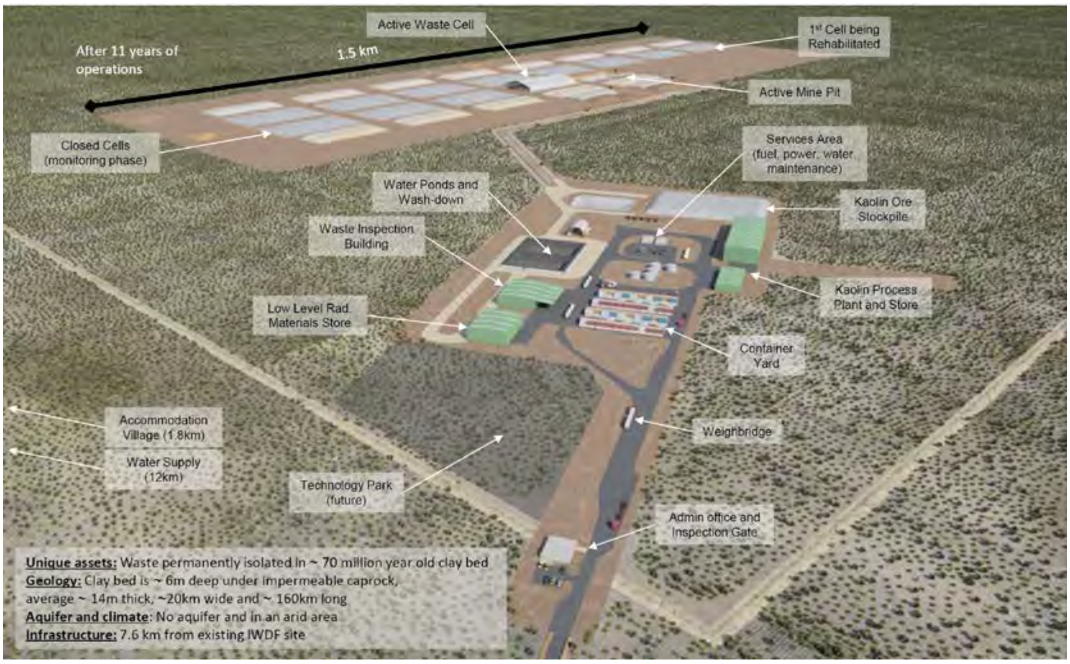
The Proposal will require planning approval, licenses and permits from both the Commonwealth Government and the WA Government. The key approvals and licenses will be sort from:

- The Australian Minister for the Environment under the provisions of the EPBC Act and Environment Protection and Biodiversity Conservation Regulations 2000 (EPBC Regulations). The EPBC Act and EPBC Regulations are administered by the Commonwealth Department of the Environment and Energy (DoEE).
- The WA Minister for Environment, Heritage under Part IV of the EP Act and the Environmental Impact Assessment (Part IV Divisions 1 and 2), Administrative Procedures 2012. The EP Act and the Environmental Impact Assessment (Part IV Divisions 1 and 2), Administrative Procedures 2012 are administered by the WA Office of the Environmental Protection Authority (OEPA).
- The WA Minister for Mines and Petroleum for a mining lease under Section 71 of the *Mining Act 1978* supported by a Mining Proposal and a Mine Closure Plan.

Overall approval is sought under the EPBC Act and EPBC Regulations (administered by the DoEE) and the EP Act and Environmental Impact Assessment (Part IV Divisions 1 and 2), Administrative Procedures 2012 (administered by the OEPA) via a bilateral agreement between the Australian Government and the WA Government.

Proposal definition

Tellus propose to develop an open-cut kaolin mine and complementary storage facility with supporting above ground infrastructure that would export up to 40,000 tonnes per annum (tpa) of refined kaolin for ceramic paint and other industrial uses. The storage facility would provide for the safe and secure storage and permanent isolation of an average of 66,000 tpa but up to 100,000 tpa of waste. The open cut kaolin mine and complementary storage facility is referred to as the Sandy Ridge Facility. An artist impression of the proposed Sandy Ridge Facility is provided below.



Aerial view of the proposed Sandy Ridge Facility. Mining pit/cells are located in the background. Supporting aboveground infrastructure is located in the foreground.

Kaolin mining

Kaolin would be extracted using the open cut method of mining. The surface of each pit would be cleared of vegetation and stockpiled (for later reuse in rehabilitation). The pit would then be opened by excavation of the topsoil, subsurface soils and laterite. Following this, there would be carefully controlled blasting using explosives or continuous mining of the hard, dense silcrete layer that overlays the kaolin, and then removal by excavator and truck. The kaolin would then be recovered by conventional earthmoving equipment (front end loader, excavator and articulated dump trucks). Overburden would be stockpiled adjacent to the cells in readiness for backfilling. Separate stockpiles of different grades of kaolin ore would be located adjacent to each pit or at the proposed kaolin processing plant.

Up to 40,000 tpa of kaolin would be extracted. The ore would be processed via an onsite wet processing plant. The kaolin would then be packaged and transferred from the Sandy Ridge Facility via road to the domestic market or to Fremantle Port for export overseas.

Conceptual view of pit being mined. Roof canopy is erected at the later stages of kaolin mining, prior to waste emplacement to prevent rainfall from entering the waste cell.

Waste storage and isolation

Waste would be transported mostly via rail to Kalgoorlie and then by road by reputable licensed transport contractors to the proposed Sandy Ridge Facility. Waste arriving would be inspected, sampled, unloaded and stored in line with a strict Waste Acceptance Criteria (WAC) and in accordance with operational management plans.

Open cut kaolin mine creates the voids (left). The voids are used for the safe and secure storage of waste in sealed containers (right).

The mining pits (now referred to as waste cells) would be filled with packaged waste in layers. Waste types would be placed ‘like-with-like’ for safety reasons, with multiple sections in each layer (to separate the different waste types). The space between the waste packages would then be backfilled with kaolin clay and compacted to minimise air or void space. Each layer would also be compacted, until approximately 7 m below the ground surface. At this depth, a thick layer of low permeability clay would be placed on top of the waste to seal the waste layers and to prevent water ingress into the cell. Compacted gravel and laterite backfill would then be placed on the clay layer. A clay domed cap would then be situated on the top of the cell, to horizontally shed any landing rainfall for the duration of a subsidence monitoring period. At the completion of the subsidence monitoring period, soil would be placed over the domed clay cap to enable re-vegetation.

During the waste storage and isolation process, a roof canopy would be positioned over the cell to exclude rainfall prior to the capping layer being installed.

The cells would be designed and managed to allow for future waste recovery opportunities – that is, wastes would be stored like-with-like and the final disposal locations of all waste would be tracked and logged for future reference. At some point in the future, a recovery technology park would be established to support research and development into ways to release waste materials back into the circular economy.

In the first year of operation, about 42,500 tpa of waste material would be disposed of at the Facility. This may increase up to 100,000tpa, but likely to average 66,000 tpa over the life of the facility.

Tellus supports the circular economy with the development of the proposed Sandy Ridge Facility

Hazardous and intractable waste primarily from the mining, oil and gas, chemical, manufacturing, agricultural, and remediation industries would be accepted at the proposed Sandy Ridge Facility. Wastes would also be accepted from the State Emergency Services such as hazardous material resulting from man-made or natural disasters. Accepted waste materials would come from WA, the Australian mainland and Australian waters.

Key infrastructure

Infrastructure that would be constructed and used for the mining operation includes:

- Open cut mining pits (later used as waste cells) approximately 120 m long, 60 m wide and 23 m deep (depending on local stratigraphy, with a maximum depth of 30 m). Twenty-five pits are currently proposed.
- A kaolin processing plant.
- A kaolin ore stockpile area (run of mine [ROM] pad).
- A finished product (kaolin) storage building.
- A laboratory.
- Mining contractor offices and laydown yard including repair and maintenance facilities for earthmoving and plant equipment, saline water ponds, reverse osmosis plant, and an explosive magazine.

Infrastructure that would be constructed and used for the waste storage operation includes:

- Waste cells created by the pits (voids) left from the mining operation.
- Relocatable waste cell roof canopy on a rail system.
- Container hardstand.
- Waste inspection area.
- Radioactive waste warehouse and packaging building.
- A waste laboratory.
- A waste solidification and stabilisation facility comprising waste storage, consumables storage and blending and mixing equipment. This is anticipated to be similar in size and layout to a small concrete batching plant.
- Truck and machinery wash-down pad, wash-down water system (including treatment and storage), front gate office, secure site fencing and gatehouse incorporating a computerised weighbridge.

In addition to the above infrastructure, the following activities would be undertaken:

- Upgrade of the IWDF access road and intersection at Great Eastern Highway.
- Construction of the site access roads and internal haul roads.
- Construction of a mobile and permanent accommodation camp.
- Construction of a water pipeline and associated pump station at the Carina Mine pit.
- Construction of administration building and carpark (including offices, first aid, training centre, communications, lunch room, and ablutions).

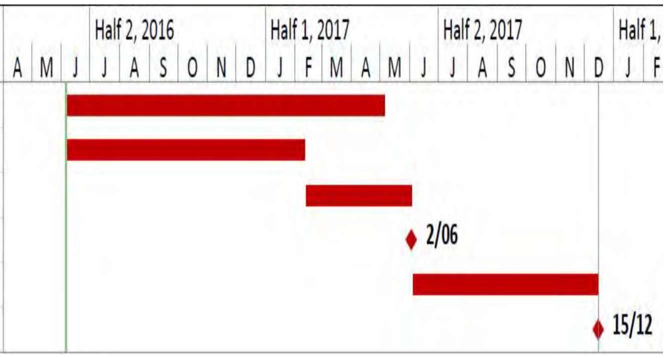
- Excavation of a trench at the Class II putrescible landfill location and erection of a fence around the landfill.
- Installation of sewage treatment systems.
- Installation of water tanks for raw and potable water.
- Installation of diesel storage tanks, piping reticulation and bowser.
- Installation of drying process fuel storage tanks.
- Installation of switchboards and generators.
- Erection of a fence around infrastructure area and pits/cells.

Timeline

Subject to obtaining approval, it is anticipated that construction of the Proposal would commence in mid-2017, with operation commencing at the end of 2017. A likely timeline for the Proposal is presented in Table E-2.

Table E-2 Likely Proposal timeline

Task Name	Start	Finish
Approvals	Mon 6/06/16	Fri 5/05/17
Bankable Feasibility Study	Mon 6/06/16	Fri 10/02/17
Front End Engineering & Design	Mon 13/02/17	Fri 2/06/17
Final Investment Decision	Fri 2/06/17	Fri 2/06/17
Construction (Stage 1)	Mon 5/06/17	Fri 15/12/17
Operation (Stage 1)	Fri 15/12/17	Fri 15/12/17



Stakeholder consultation and engagement

The proponent commenced initial consultation in August 2012. The steps involved in the consultation process included the identification of key stakeholders, the development and implementation of a consultation and engagement strategy and recording stakeholder feedback.

Stakeholders were identified as individuals or organisations that may be interested in or affected by the Proposal. A consultation and engagement strategy was developed to ensure effective and timely consultation activities during the development of both the ESD and PER.

Community engagement (Kalgoorlie)

Stakeholders were engaged using a range of consultation and communication techniques, including face-to-face meetings, workshops, community information sessions, telephone and email communications, as well as media releases and website updates. These were supported by stakeholder feedback mechanisms, including a company-specific email address.

Key stakeholders were offered the opportunity to provide feedback and raise issues during the development of the draft ESD and PER. The key stakeholders included government agencies, non-government organisations, industry and business, landholders, traditional owners and residents of the surrounding communities and potential customers.

Communication tools used during community information sessions

Early stakeholder consultation helped shape the technical studies for the PER. Government feedback also influenced the design of the Proposal.

Stakeholder consultation will be ongoing throughout the environmental impact assessment process. If approved, consultation would continue through site preparation and construction and during operation of the Proposal, where information would be provided to stakeholders on a regular basis.

Key environmental factors

The key environmental factors identified in the ESD include:

- Flora and vegetation.
- Terrestrial environmental quality.
- Terrestrial fauna.
- Inland waters environmental quality.
- Human health.

- Heritage.
- Offsets (integrating factor).
- Rehabilitation and decommissioning (integrating factor).

In addition, amenity (in relation to noise, dust and visual impacts) as well as cumulative impacts are considered relevant to the Proposal.

Environmental risk assessment

An environmental risk assessment was undertaken to identify, evaluate and mitigate the potential environmental impacts of the Proposal. As the environmental impact assessment included input from a wide range of technical disciplines, a standardised environmental risk assessment was undertaken to ensure consistency in determining the level of risks. This standardised approach did not replace the methodologies used by technical disciplines to identify or assess impacts, nor did it replace methods of impact assessment prescribed by existing guidance. Rather, it supplemented the impact assessment by providing clear, more readily comparable conclusions regarding the significance of impacts.

The standardised risk assessment for the Proposal involved:

- Defining the sensitivity of environmental and social values, resources and receptors.
- Describing the potential impacts that may arise as a result of the Proposal.
- Assessing the likelihood of an impact occurring.
- Assessing the probability of an impact occurring.
- Evaluating the consequence of an impact.
- Identifying outline management and/or mitigation measures and evaluating the residual impact.
- Assigning an overall risk rating.

The environmental and social systems, resources and receptors potentially affected by the Proposal were defined through desktop-based research, field surveys and consultation with local communities, regional stakeholders, and with key agencies within the WA Government.

As the Proposal develops into detailed design, construction and operation, risk assessments would be undertaken at each milestone.

Assessment of key environmental factors

Extensive investigations have been undertaken to describe the existing (baseline) environment and to assess the potential environmental impacts during construction, operation, decommissioning and closure of the Proposal. These included specialist studies of flora and vegetation, geological evolution, soils and landform, fauna, hydrology and hydrogeology, infiltration and seepage, heritage, and radiation. Environmental mitigation and management measures have been identified to avoid and minimise potential impacts and to protect the environment. A summary of the environmental assessment is provided below.

Flora and vegetation

A flora and vegetation assessment was undertaken to assess the potential impacts to flora and vegetation during construction and operation of the Proposal. The flora and vegetation assessment included a review of previous flora and vegetation surveys in the region, review of aerial photography and contour maps, a review of publicly available databases for conservation significant flora and vegetation communities that may be affected by the Proposal and a field survey.

Flora and vegetation surveys

A range of different vegetation associations and vegetation types were recorded within the proposed development envelope and vicinity. The proposed development envelope consists of open woodland and shrublands dominated by *Acacia* and *Eucalyptus* spp. Open heaths are dominated by *Leptospermum* sp. All of the vegetation types are considered common and widespread within the region. Most of the vegetation within the proposed development envelope is considered to be in excellent condition.

There are no Priority Ecological Communities listed by the Department of Parks and Wildlife (DPAW), Threatened or Endangered Ecological Communities listed under the *Wildlife Conservation Act 1950* (WC Act) or Threatened or Endangered Ecological Communities listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) within the proposed development envelope.

Direct impacts on terrestrial flora and vegetation during construction and operation of the Proposal include the removal of vegetation and impacts to land managed by the DPAW. Up to 276.05 hectares (ha) of native vegetation would be removed for the construction and operation of the Proposal. Of this, approximately 13.32 ha of vegetation would be removed within the former Jaurdi Pastoral Lease, which includes 6.44 ha of vegetation within a proposed Conservation and Mining Reserve (both managed by DPAW). The removal of this vegetation would be negligible given the expanse of similar vegetation in the general vicinity of the Proposal.

There would be no impact to conservation significant flora or vegetation listed under the WC Act or the EPBC Act. Conservation significant flora populations would not be cleared during either construction or operation of the Proposal.

Two flora species of conservation significance were recorded within the proposed development envelope. These were *Calytrix creswellii* and *Lepidosperma lyonsii* (both listed as Priority 3 by the DPAW) and are not protected by environmental legislation. In addition, an undescribed sedge species was also recorded within the proposed development envelope – *Lepidosperma* sp. This species is currently undescribed and may have some conservation value.

The taxonomy of the *Lepidosperma* sp. is currently being reviewed by the WA Herbarium. Its conservation status is currently unknown. Until the taxonomy and conservation status of this species is known, it is difficult to predict impacts to this species during construction and operation of the Proposal. If the species is deemed to have conservation significance, surveys would be undertaken prior to construction to confirm the presence/absence of the species within the proposed development envelope. If the species is found to be present, significant impacts would be avoided through changes to the location of the proposed infrastructure, if possible. Alternatively, a translocation program developed in consultation with DPAW would be implemented to avoid significant impacts to this species. If significant impacts could not be avoided, the need to calculate and deliver biodiversity offsets would be assessed in accordance with the *Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy* and in consultation with the DoEE and/or DPAW, as appropriate.


***Acacia resinmarginea* Open Heath is one of the most dominant vegetation types within the proposed development envelope.**

Indirect impacts on flora and vegetation may include an increased incidence of fire, altered hydrology, increased dust, the uptake of saline water, and the introduction and spread of weeds. The potential for radiation exposure and the transpiration of leachate from the waste cells would not likely occur.

Mitigation and management measures would be implemented to avoid (eliminate) or reduce these impacts including ensuring that vegetation clearing is kept to a minimum, ensuring populations of conservation significant flora are clearly marked and avoided, implementing dust suppression and management measures, monitoring vegetation health to determine if water ponding/water starvation is occurring and incorporating a weed management plan into the construction and operational environmental management plan for the Proposal.

Terrestrial environmental quality

Topography and landforms within and in the vicinity of the proposed development envelope was determined based on a desktop review of publicly available information, a review of aerial photography and via a field reconnaissance survey. A regional geology and geological evolution assessment was also undertaken in order to understand and describe the geology within and in the vicinity of the proposed development envelope. This included a desktop review of publicly available information, a review of geological mapping and a field reconnaissance survey.

A baseline soils assessment was undertaken to characterise and quantify the soil resource within the proposed development envelope. The baseline soils assessment included a review of publicly available information, a field assessment (which included the excavation of soil pits to collect soil samples and to log soil profiles), physical and chemical analysis of collected soil samples and interpretation of results and soil mapping of the proposed development envelope.

Geological assessment

The proposed development envelope has very low relief. It consists of flat to gently undulating plains and low rises and is typical of landscape which occurs over deeply weathered granite rocks. The topography ranges from about 460 m above sea level to 490 m above sea level and generally rises slightly from west to east.

The geology of the proposed development area is well understood due to mineral exploration drilling across the exploration tenement. In geological terms, the proposed development envelope is a deeply weathered granitoid terrane that generally comprises four main lithologies. From the surface these are: colluvial and gravel with mottled zone laterite; silcrete, kaolinitic clay; and granitoid basement. Current weathering and erosion in the area is extremely slow. The semi-arid climate, with a median annual rainfall of about 250 mm and an annual evaporation rate over 2,000 mm is not conducive to chemical weathering.

Two soil types occur within the proposed development envelope. These are deep yellow sand and red sandy duplexes. The deep yellow sand is associated with the higher relief areas within the proposed development envelope. The red sandy duplexes are associated with the lower lying areas within the proposed development envelope and are areas potentially subject to erosion.

Impacts to the quality of land and soils during the construction and operation of the Proposal may include the degradation of stockpiled soils; soil contamination from leaks/spills; and a change in landform upon closure of a cell. Mitigation and management measures would be implemented to avoid (eliminate) or reduce these impacts including implementing stockpile management measures (maximum height restrictions, seeding to reduce erosion, monitoring for erosion and weed infestation), implementing spill response procedures and implementing traffic management procedures to avoid potential spills.

Other potential impacts include radiation impacts on surrounding land and soils, and the subsidence and instability of waste cells/pits allowing infiltration of water and the potential generation of leachate. These would be highly unlikely given that the Proposal has been specifically designed to avoid these impacts.

Terrestrial fauna

A terrestrial fauna assessment was undertaken to assess the potential impacts to fauna during construction and operation of the Proposal. The fauna assessment included a review of previous fauna surveys in the region, a review of publicly available databases for conservation significant fauna that may be affected by the Proposal and a field reconnaissance survey that included a habitat assessment. Targeted threatened fauna searches were also undertaken for *Leipoa ocellata* (Malleefowl).

Fauna surveys

Two fauna habitats were recorded within the proposed development envelope. These included open woodland and shrublands.

Evidence of two fauna species of conservation significance was recorded within the proposed development envelope. These were *Leipoa ocellata* (Malleefowl) (listed as Vulnerable under the WC Act and the EPBC Act) and *Merops ornatus* (Rainbow Bee-eater) (listed as Migratory under the WC Act and the EPBC Act). An additional four conservation significant species may possibly occur within the proposed development area. These species include *Nyctophilus(timoriensis)* sp. 1 (Central Long-eared Bat), *Platycercus icterotis xanthogenys* (Western Rosella (Mallee)), *Apus pacificus* (Fork-tailed Swift) and *Falco peregrinus* (Peregrine Falcon).

Direct impacts on terrestrial fauna during construction and operation of the Proposal include the loss of habitat through the removal of native vegetation. The removal of up to 276.05 ha of native vegetation would result in the loss of fauna foraging, breeding, roosting, sheltering and/or dispersal habitat. The removal of this habitat would have a negligible impact on fauna present in the vicinity of the Proposal given the presence of large areas of suitable adjoining habitat.

Clearing of vegetation would unlikely have a significant impact on conservation significant fauna listed under the WC Act or the EPBC Act. All would readily move to adjacent undisturbed habitat once vegetation clearing commences.

Indirect impacts may include those associated with increased light, noise and vibration; fauna displacement, increased predation and competition for resources; fire; increased feral fauna attracted to water and food resources; and injury or death from fauna ingress into a cell or from collisions. Impacts associated with radiation exposure and the generation of void space and subsequent collapse/instability of the waste cell are highly unlikely to occur.

Mitigation and management measures would be implemented to avoid (eliminate) or reduce these impacts including pre-clearing surveys (and capture/relocation, if necessary), ensuring clearing is kept to a minimum and conducted in stages, ensuring that an experienced spotter/handler is present onsite during clearing activities, ensuring there is no driving off designated access roads, limiting night driving and restricting speed limits, implementing vehicle strike procedures and designing infrastructure to deter fauna from accessing operational areas.

Inland waters environmental quality

A hydrological (surface water) study of the proposed development envelope was undertaken. The hydrological study included:

- Demarcation of the catchment areas and waterways likely to impact on the cell/pit area, infrastructure area and access road.
- A hydrological analysis of relevant catchment areas in order to estimate peak run-off for rainfall events between 1 and 2 year and 1 in every 100 years average recurrence intervals, and the extreme probable maximum precipitation (which is a 1 in 2,000 year event).
- Examination of historical rainfall records for nearby weather stations in order to assess the maximum total rainfall and average recurrence intervals.
- Preparation of intensity frequency duration rainfall curves using the polynomials as recommended by the Australian Rainfall and Run-off Publication (ARR, 1987).
- Examination of recorded total losses due to evaporation and infiltration in the Mount Walton area in order to estimate realistic peak flows.
- Completion of a surface water hydraulic analysis in order to assess the extent, depths and velocities of natural flow paths likely to impact the cell/pit area, infrastructure area and access road.
- Design and recommendations for preliminary concept flood protection levees for the cell area, infrastructure area and waterway crossings along the access road.

A hydrogeological (groundwater) study of the proposed development envelope was also undertaken. The groundwater study included a desktop review of regional hydrogeology (which included a review of publicly available mapping, databases, and previous hydrogeological and geotechnical drilling results from other investigations in the vicinity of the proposed development envelope) and a field investigation (which included drilling bores to depths ranging from 21 metres (m) to 49 m below ground level).

No channels or creeks occur within the proposed development envelope. There are no major flow paths in the area of the proposed cells/pits, and surface water runoff would only be generated from very infrequent high rainfall events. These flows would be from small local catchments which drain residual runoff after infiltration losses, to low–lying depressions. Generally, surface water would only be retained for short periods in the depressions due to continual evaporation and infiltration.

Extensive groundwater investigations (undertaken within the proposed development envelope and vicinity by others previously and for the Proposal) have revealed that there is no groundwater aquifer present in the proposed development envelope.

Seven monitoring bores were drilled to confirm the absence of groundwater (left). Equipment was installed to confirm soil evaporation rates (right).

Impacts to groundwater and surface water during construction and operation of the Proposal may include contamination from leaks/spills and from water entering an open cell/pit. These impacts would be minor, however, as the Proposal has been specifically cited in an area where there is no groundwater aquifer or surface water receptors present. Surface water flows are generated only under extreme rainfall events and there is a both high evaporation rates and high infiltration rates into the sandy soils present in the proposed development envelope. Mitigation and management measures would be implemented to avoid (eliminate) or reduce impacts including implementing spill response procedures and by implementing controls to prevent water ingress into the cell during operation (roof canopy, diversion levees, bunding, drains and sumps). Following closure of the cells they are expected to be stable, with no water ingress.

Other impacts include the generation of leachate from a stored waste package which may contaminate surface water runoff and groundwater. These would be highly unlikely given that the Proposal has been specifically designed (engineered) to avoid these impacts. The location of the Proposal has also been specifically selected for its natural abilities to avoid leachate generation. The natural climatic and geological conditions within the proposed development envelope reduce the chance of water infiltration and the generation of a groundwater table at the site.

Human health

An assessment of the potential impacts on human health during construction and operation of the Proposal was undertaken. This included a baseline radiation and metals assessment and a worker dose assessment.

Activities or situations considered to pose the greatest potential risk for adverse human health effects include the mining of kaolin; the acceptance and handling of hazardous and intractable waste; the storage and containment of hazardous and intractable waste; and bushfire. These activities/situations may result in injury, illness or possibly death.

Mitigation and management measures would be implemented to reduce human health impacts during both construction and operation of the Proposal. This would include the development of a detailed Safety Case and Operating Strategy. The implementation of these plans and procedures would minimise the risk of adverse impacts to human health to as low as reasonably achievable.

Heritage

A cultural heritage assessment was undertaken to assess the potential impacts to heritage (Aboriginal and European) during construction and operation of the Proposal. The heritage assessment included a desktop review of previous heritage surveys and relevant heritage databases to determine whether there were any listed heritage sites within or in close proximity of the proposed development envelope. A field survey consisting of pedestrian transects was also undertaken in consultation with representatives of the Kapam Native Title Group, Kelamaia Kabu(d)n and Widji Group.

There are no known records of heritage items within the proposed development envelope. This was confirmed via the field survey. Therefore, there would be no impact to cultural heritage during construction or operation of the Proposal. In the event that items of potential European historical significance are encountered, work in their immediate vicinity (defined as a 10 metre radius) would stop and the Heritage Council and State Heritage Office would be contacted. Similarly, if items of Aboriginal heritage significance are identified during construction, work in their immediate vicinity would stop and the Department of Aboriginal Affairs in addition to the Kaparn Native Group, Kelamaia Kabu(d)n and Widji Group would be contacted for further advice.

If suspected skeletal remains are discovered during construction, work in their immediate vicinity would stop and the local police and the Department of Aboriginal Affairs would be notified as soon as possible to determine a course of action. Construction works in the area of the remains would not resume until the proponent receives written approval from either the police or from the Department of Aboriginal Affairs, as appropriate.

Offsets

An assessment of the residual impacts on flora and vegetation and terrestrial fauna was undertaken in accordance with the *Environmental Offsets Guidelines* (Government of Western Australia, 2014). The only issue which potentially triggers a requirement for an offset relates to the clearing required within the former Jaurdi Pastoral Lease (of which 6.44 ha is located within a proposed Conservation and Mining Reserve). As this area is only a proposed reserve at this stage and vegetation is sparse with no conservation significant flora or fauna present within the 6.44 ha area, the potential impact is not considered to be significant enough to warrant an offset.

Rehabilitation and decommissioning

Potential impacts during rehabilitation and decommissioning include the subsidence of a waste cell allowing infiltration of water and the generation of leachate; topsoil degradation; erosion/gullies/deep rooted vegetation creating cracks in the clay capping allowing infiltration of water and the generation of leachate; vegetation not growing and unable to support a functioning ecosystem; fauna not returning and a functioning ecosystem is not achieved; and long term impacts on terrestrial environmental quality, inland waters and human health.

Two closure and decommissioning plans would be implemented in order to avoid (eliminate) or reduce the potential impacts associated with rehabilitation and decommissioning of the Proposal. Two plans would be implemented, primarily as the regulation of mining and waste disposal and are managed under different legislation in WA:

- Mining aspect – details relating to mine closure for tenement relinquishment would be outlined in a Mine Closure Plan (MCP).
- Waste storage and isolation aspect – details relating to the waste cells and associated infrastructure would be outlined in a Waste Facilities Decommissioning and Closure Plan (WFDCP).

Both documents would contain closure objectives, indicative completion criteria and key measurement tools. The measurement tools would include (but would not be limited to):

- Geotechnical assessments.
- Visual inspections.
- Safety bunding.
- Revegetation monitoring.
- Subsidence monitoring.
- Erosion, radiation and monitoring for any potential groundwater.

Environmental management

The assessment of key environmental factors (and other factors) has indicated that the Proposal would result in environmental impacts during construction, operation, rehabilitation and decommissioning. A range of management plans, protocols and procedures to manage the environmental impacts of the Proposal would be implemented.

A Construction Environmental Management Plan (CEMP), Operational Environmental Management Plan (OEMP) and a Waste Facility Decommissioning and Closure Plan (WFDCP) and Mine Closure Plan (MCP) would be prepared and implemented for the Proposal. The plans would include:

- Environmental objectives and performance targets for construction, operation, and rehabilitation and decommissioning.
- Required statutory and other obligations, including consents, licences, approvals and voluntary agreements.
- Management policies, procedures and review processes to assess the implementation of environmental management practices and the environmental performance of the Proposal against the objectives and targets.
- Requirements and guidelines for management in accordance with:
    - Conditions of consent for the Proposal.
    - Mitigation measures specified by this PER.
    - Relevant management guidelines.
- Requirements in relation to incorporating environmental protection measures and instructions in all relevant standard operating procedures and emergency response procedures.
- Specific procedures, including monitoring, as defined by the PER and the conditions of consent.
- Roles and responsibilities of all personnel and contractors to be employed on-site.
- Procedures for complaints handling and ongoing communication with the community.
- Environmental sub-plans.
- Incident response procedure.
- Monitoring and auditing program.

An environmental monitoring program would be implemented that enables auditing of mitigation measures to ensure they achieve their objectives and to facilitate modification, where necessary. An environmental monitoring program would be established for both the construction, operational, and rehabilitation, decommissioning and closure phases of the Proposal.

Environmental management information and data would be stored in Tellus' existing Environmental Management System (EMS). The Tellus EMS is accredited to Australian and New Zealand Standards (AS/NZS) ISO 14001:2004 Environmental Management Systems. It is regularly audited internally, and annually audited by an external party.

Justification and conclusion

The Proposal is considered justified because it:

- Provides diversity in the WA mining sector.
- Responds to a recognised need and is consistent with WA and national waste management strategies in addition to regional economic strategies and plans.
- Provides a number of community and economic benefits including opportunities for the long-term, storage, treatment and recovery of valuable materials or the permanent isolation of hazardous, intractable and LLW in addition to long-term full-time employment.
- Would not result in significant effects on the environment.
- Is consistent with the principles of sustainability and environmental protection.

Proceeding with the Proposal would result in significant social and economic benefits, including:

- Providing a unique dual revenue business that commercialises an industrial bulk commodity (kaolin) and provides safe management solutions for difficult to manage hazardous waste resources.
- Future potential recovery of valuable materials.
- Long-term jobs and major investment and business opportunities in remote regional Australia.
- Diversification of the economy by an environmental infrastructure business with strong social, environmental and economic values.
- Royalties, taxes and levies over the 25 year term could support other parts of the economy.
- Employment and business opportunities that can support local and regional communities.
- Long project life of 26 years (1 year build, 25 year operation). The site can be expanded for generations.
- Creation of approximately 90 jobs during the construction phase, and approximately 23 direct and 46 indirect (2x multiplier) during the operation phase.
- Benefits would apply to local indigenous communities where opportunities for training, employment and business opportunities during construction and operations exist.
- When operating, the Facility would also provide a reliable long-term utility service to other industries that produce waste materials within Australia.
- The Facility could attract new kaolin and waste recycling and recovery industries to WA, and support industrial development in WA, bringing attendant economic benefits.

Detailed scientific desktop and field investigations were undertaken to assess key environmental factors and to discuss their potential environmental impacts, positive or negative, during each phase of the Proposal. These included specialist studies of biodiversity, soils, cultural heritage, surface water, groundwater and radiology. These studies were undertaken in accordance with relevant Commonwealth and State environmental legislation, guidelines and procedures established by regulatory agencies.

Based on the findings of the environmental investigations, it is likely there would be some minor but manageable adverse impacts on the environment. Mitigation measures that would be implemented during all phases of the Proposal have been recommended to avoid (eliminate) or ensure potential impacts are short-term and easily managed. The environmental performance of the Proposal would be managed through the implementation of a CEMP, OEMP and WFDCP and MCP. This would also help to ensure compliance with relevant legislation and any conditions of approval.

A summary of the Proposal is presented below.

Summary of the Proposal		
Proposal title	Sandy Ridge Facility.	
Proponent name	Tellus Holdings Ltd.	
Short description	The Proposal is to develop a kaolin open cut mine and use the voids resulting from mining for the secure storage and isolation of hazardous, intractable waste and LLW using an international best practice storage and isolation safety case. The Proposal is located approximately 75 km north-east of Koolyanobbing, WA (Figure 1-1).	
PHYSICAL ELEMENTS		
Element	**Location**	**Proposed Extent Authorised**
Pits/Cells	Figure 1-3	Clearing no more than 202.3 hectares (ha) within 1004.2 ha proposed development envelope.
Mine infrastructure	Figure 1-3	Clearing no more than 17.2 ha within 1004.2 ha proposed development envelope.
Accommodation camp	Figure 1-3	Clearing no more than 2.5 ha within 1004.2 ha proposed development envelope.
Class II Landfill	Figure 1-3	Clearing no more than 0.25 ha within 1004.2 ha proposed development envelope.
Future technology park	Figure 1-3	Clearing no more than 4 ha within 1004.2 ha proposed development envelope.
Access roads	Figure 1-4	Clearing no more than 22.2 ha within 1004.2 ha proposed development envelope.
Water pipeline	Figure 5-1	Clearing no more than 27.6 ha within 1004.2 ha proposed development envelope.
Total disturbed area		Clearing no more than 276.05 ha within 1004.2 ha proposed development envelope.
OPERATIONAL ELEMENTS		
Element	**Location**	**Proposed Extent Authorised**
Ore Processing	Kaolin Plant, Figure 1-3, coordinates: 220800mE, 6637520mN	Kaolin plant design capacity per annum 40,000 t. Maximum amount disposed 1,000,000 t over a 25-year period
Class IV and Class V waste disposal	Pits/Cells, Figure 1-3 coordinates: 219920mE, 6638195mN	Disposal of no more than 100,000 tpa[1] Average amount per annum 66,000 tonnes (t) Maximum amount disposed 2,500,000 t over a 25 year period.
Class II Landfill for waste generated on the site	Class II Landfill, Figure 1-3 coordinates: 218507mE, 6637370mN	Disposal of no more than 500 tpa.
Water Use	Water Tanks, coordinates: 220770mE, 6637430mN	0.18 gigalitres per annum sourced from water tanks onsite that are supplied via a water pipeline from the Polaris/Mineral Resources Carina Iron Ore Mine.

[1] *The exact volumes of hazardous and LLW wastes can not be defined at this stage of project development. Subject to planning approval, there would be more certainty with respect to potential waste volumes.*

Part A

Introduction and Assessment Framework

Volume 1

Proposal Background

TELLUS

1 INTRODUCTION

1.1 Introduction

Tellus Holdings Ltd (Tellus) is the proponent for the Sandy Ridge Facility (herein referred to as the 'Proposal' and/or the 'Facility'). The proponent is an infrastructure development company in the business of creating economic, social and environmental value from waste and clay resources. This dual revenue model involves mining kaolin clay in a thick, dry, remote location which is based on world's best practice near surface geological repositories. The voids created by mining are then used to store equipment, archives and waste using a multi barrier system as part of an overall safety case. The proponent plans to permanently isolate hazardous and intracble waste using environmentally sound management principles, that protect the environment and human health.

The proponent also supports the circular economy using long term storage by placing like-with-like materials for operational safety reasons and, to create opportunities for the future recovery of valuable materials. The proponent's business model mirrors international solutions operating in the United Kingdom, Europe and North America.

The proponent is developing the proposed Facility at Sandy Ridge in Western Australia (WA) located approximately 75 kilometres (km) north-east of Koolyanobbing, in the Shire of Coolgardie, within the Goldfields Region of WA (refer to Figure 1-1). This Public Environmental Review (PER) addresses a proposal to construct and operate an open-cut kaolin mine, storage and isolation facility for hazardous and intractable wastes.

There are two key aspects of the Proposal. The first involves mining kaolin primarily for export to Asia for ceramic clay and paint market. The second involves storing hazardous and intractable chemical wastes (approximately 99 % of the planned volume) and low level radioactive wastes (LLW), such as smoke detectors and sealed gauges (approximately 1 % of the planned volume) within the void spaces left from the mining operations.

This PER has been prepared to support the approval of the Proposal under Part IV of the *Environmental Protection Act 1986* (WA) (EP Act) and the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act). The PER has been prepared to address the requirements set out in the final Environmental Scoping Document (ESD) for the Proposal issued by the WA Office of the Environmental Protection Authority (OEPA) on 27 May 2016 (refer to Appendix A.1). A cross reference of this PER against the ESD requirements are also contained within Appendix A.1.

The PER has also been prepared to address the requirements set out in Schedule 4 of the Environment Protection and Biodiversity Conservation Regulations 2000 (Cth) (EPBC Regulations).

1.2 Proposal overview

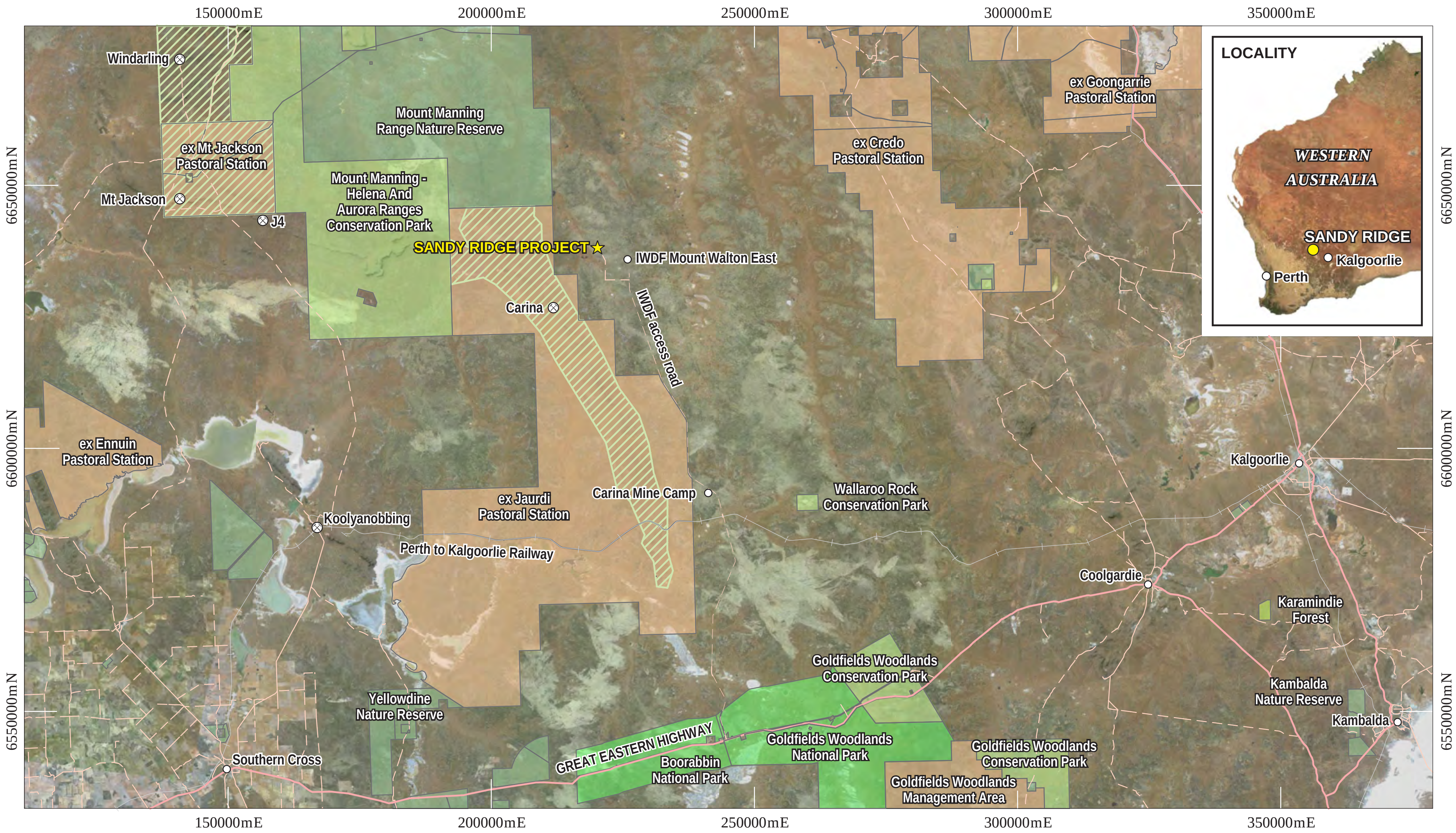
The proponent is seeking environmental approval to construct and operate a dual revenue business. The first aspect of the dual revenue model relates to the mining, processing and export of kaolin. The second aspect relates to the emplacement and permanent isolation of hazardous, intractable chemcical waste as well as LLW in the mine voids. The placement of these wastes in a near surface geological repository, based on international best practice techniques, would isolate the wastes from the biosphere over geological time.

1.2.1 Kaolin mining

The Proposal based on a maximum 40,000 tpa kaolin processing plant design, up to 2.9 million tonnes of kaolin clay needs to be mined (run of mine – ROM). From the ROM, up to 1.0 Mt of processed kaolin clay over 25 years could potentially be mostly exported to Asia. The kaolin would be transferred from Sandy Ridge to the domestic market or to Fremantle Port for export into the Asian market. The kaolin would be used mostly in the ceramic market (refer to Plate 1–1). Other potential uses include paint manufacturing or the development of fibre glass that is used in manufactured products like wind turbines.

Plate 1-1 Process from the proponents drilling, to bulk pilot, to producing ceramic grade products

All overburden (laterite, silcrete, yellow sand) and kaolin that is not acceptable for export would be returned to the mine voids (herein referred to as 'cells') for use in backfill around buried waste. Kaolin would also be used to cap the cell after it has been completely filled with waste materials.



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

TELLUS

N

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

Regional location

Public Environmental Review

Figure:

1-1

1.2.2 Waste storage, recovery and isolation services

What is hazardous waste?

Hazardous waste in Australia is regulated by the states and territories, which variously describe these waste types as controlled, trackable, prescribed, listed or regulated wastes. Hazardous waste is waste that is a management problem by virtue of its toxicity or chemical or physical characteristics which make it difficult to dispose of or treat safely and which is not suitable for disposal in a Class I, II, III or IV landfill, but is suitable in a geological repository (Class V) like the proposed Sandy Ridge Facility.

Overview of waste storage, recovery and isolation services

For planning purposes, Tellus is assuming the Proposal would start at below 50,000 tpa, average 66,000 tpa over 25 years, but would have a licenced capacity of 100,000 tonnes per annum of Class IV and V Hazardous and Intractable wastes to accommodate for both a steady state growth over 25 years and a surge as a result of a one-off campaign style State Emergency Service infrastructure requirements. For example, man-made or natural disasters where significant volumes of materials need to be rapidly removed from communities, or one off campaign style transfer of significant mine dumps or tailing ponds from a large industrial customer.

The Facilities' primary objective is to provide customers with a licensed facility that safely allows for the storage, treatment, recovery and permanent isolation of bulk hazardous and intractable chemical waste materials. Some of these materials may be classified as dangerous or hazardous goods, such as those listed wastes under Schedule 1 of the National Environment Protection (Movement of Controlled Waste between States and Territories) or National Environment Protection (Movement of Controlled Waste between States and Territories) Measure 1998 (NEPM) 75.

The Facility may receive Naturally Occurring Radioactive Material (NORM) up to a low level radioactive waste level (LLW) of activity arising mainly from the mining, oil and gas and agricultural fertiliser, smelting industry. The proponent will be applying for a Licence (Controlled Action) to accept NORM up to a LLW level of activity and non-nuclear LLW such as medical isotopes, smoke detectors and sealed industrial sources. The proponent is assuming a LLW volume of approximately 1%.

Wastes would be accepted from within WA, other Australian states and territories and from Australia's Exclusive Economic Zone[2].

Australian's are one of the world's highest emitters of hazardous waste on a per capita basis. Most Australian industries and households produce hazardous waste.

---

[2] [2] Australia has an EEZ declared under the *Seas and Submerged Lands Act* Act on 1 August 1994. The inner limit of the EEZ is the outer limit of the territorial sea located 12 nautical miles seaward of the territorial sea baseline. The outer limit of the EEZ is 200 nautical miles from the baseline, except where it has been pulled back to take account of maritime delimitations or potential maritime delimitations with other countries. Except in the area of those delimitations, it is therefore 188 nautical miles wide.

The Facility would operate as a wholesale service provider that is predominantly focused on industrial generated hazardous waste. The Facility would not be open to the public (households). It could potentially receive household hazardous waste via reputable waste management companies that would collect hazardous waste from households and bring it to the Facility.

Waste acceptance criteria

Waste Acceptance Criteria (WAC) have been established for the proposed Sandy Ridge Facility to determine waste types which can and cannot be accepted to achieve safe operation and environmental protection in the longer term at our facilities. The facility has been designed and is in a dry, 70 million year old, thick, stable host geological environment (clay bed) which can store and dispose of the majority of the NEPM 75 hazardous and intractable wastes types subject to them meeting strict WAC. These criteria have been developed following internationally recognised best practice and set out waste characteristics which would and would NOT be suitable for storage or disposal in a geological repository

In the first year of operation, about 42,500 tonnes per annum (tpa) of waste material would be disposed of at the Facility. This may increase up to 100,000 tpa (licensed amount), but likely to average 66,000 tpa over the life of the proposed Facility. Wastes would be accepted predominantly from within WA but also from across Australia and from Australian Exclusive Economic Zone.

Operations

Cells would be filled in layers with multiple sections in each layer containing wastes of similar characteristics. All space between the waste packages would be backfilled and compacted to minimise air or void space, and to ensure long term stability. Each layer would be compacted, until approximately 7 m below the ground surface. A thick capping layer of low permeability clay (referred to as a ‘seal’) would be installed to prevent water ingress into the cell. Following this, more compacted backfill and a domed kaolin cap would be situated on the top of the cell to shed any landing rainfall during a monitoring period. At completion of the monitoring period soil and topsoil are replaced to allow rehabilitation. The soil layers are also an integral part of the cap system, providing a ‘store-and-release’ function for rainwater.

During the waste storage or permanent isolation process, a roof canopy would be positioned over the cell to exclude rainfall prior to the seal being installed. There may be instances (for non-soluble waste types) where a cell may be filled with waste without a roof canopy. In addition, any potential stormwater surface flows would be diverted away from the cells by bund walls or levee banks.

The entire process of kaolin mining and waste emplacement is summarised in Plate 1-2.

Plate 1-2 Process of creating the kaolin open cut pit, filling it with waste materials, and then undertaking remediation and closure

1.2.3 Classes of disposal facilities

Domestic and commercial landfills are allowed to accept waste defined under the WA *Landfill Waste Classification and Waste Definitions* (Department of the Environment and Conservation, 1996). The Proposal is seeking approval to take Class IV and Class V wastes. The waste types permitted for disposal in WA are summarised in Table 1-1 and those that would be accepted at the Facility are highlighted in orange.

Table 1-1 Landfill classes and waste types in WA

Landfill class	Description	Waste type
Class I	Inert landfill	• Clean fill. • Type 1 Inert waste. • Contaminated solid wastes meeting waste acceptance criteria specified for Class I landfills (possibly with specific licence conditions). • Type 2 inert waste (with specific licence conditions). • Type 3 inert waste (subject to DEC* approval). • Type 1 special waste.
Class II	Putrescible landfill	• Clean fill. • Type 1 inert waste. • Putrescible wastes. • Contaminated solid waste meeting waste acceptance criteria specified for Class II landfills (possibly with specific licence conditions). • Type 2 inert wastes (with specific licence conditions). • Type 1 and Type 2 Special Wastes (for registered sites as approved under the Controlled Waste Regulations).
Class III	Putrescible landfill	• Clean fill. • Type 1 inert waste. • Putrescible wastes. • Contaminated solid waste meeting waste acceptance criteria specified for Class II or Class III landfills (possibly with specific licence conditions). • Type 2 inert wastes (with specific licence conditions). • Type 1 and Type 2 special wastes.
Class IV (prescribed premises Category 65)	Secure landfill	• Clean fill. • Type 1 inert waste. • Contaminated solid waste meeting criteria specified for Class II, Class III or Class IV landfills (possibly with specific licence conditions). • Type 2 inert wastes (with specific licence conditions). • Type 1 and Type 2 special wastes.
Class V (prescribed premises category 66)	Intractable landfill	• Intractable and other wastes in accordance with the approvals for the site.

Source: *Department of Environment, 1996*
**Department of Environment and Conservation*

Waste sources

Intractable Class V wastes are those problematic by virtue of their toxicity, chemical or physical characteristics which make them difficult to dispose of or treat safely, and which are not suitable for Class I to IV landfills (DEC, 1996 as amended 2009). The sources of intractable wastes vary. Industries that generate intractable wastes include:

- ***Mining*** – industrial sludges like arsenic and cyanide from the gold industry.
- ***Oil and gas sector*** – for example hydrocarbons in contaminated soil or from processing from upstream, midstream and downstream. Note: some waste from the oil and gas industry contains naturally occurring radioactive materials (NORMs). NORM containing scale and equipment would be accepted at the facility.
- ***Heavy industry*** – for example spent catalyst wastes (aluminium slag).
- ***Agriculture*** – for example pesticides.
- ***Government*** *(state emergency service)* – waste generated due to man-made or natural disasters that needs to be removed safely from the community by Government agencies; for example, asbestos.

Table 1-2 describes the hazardous and intractable wastes accepted on site (surface) and below ground in waste cells.

Table 1-2 Hazardous wastes accepted on site (surface) and below ground in waste cells

Hazardous and intractable wastes (NEPM 75)	Accepted on site (surface storage)[2]	Accepted below ground in waste cells[2]
Hazardous and intractable wastes (NEPM 75) subject to meeting the characteristics criteria below (examples of acceptable wastes on next slides)	✓	✓
• Liquid and sludges	✓	×[1]
• Explosive wastes	✓	×[1]
• Flammable liquids or solids	✓	×[1]
• Self-combusting wastes or wastes that can generate a gas-air mixture which is toxic or explosive	✓	×[1]
• Highly corrosive or oxidizing	✓	×
• Gases	×	×
• **Clinical waste** *such as infectious hospital waste and body parts*	×	×
• **Municipal Solid waste** *such as putrescible household and commercial waste*	×	×
• Putrescible wastes *which rot such as household rubbish*	×	×
• Uncertified waste *which can not be identified or has not undergone characterisation testing*	×	×
• Reacts with the repository geology *such as dissolving it or producing a gas*	×	×

[1]*Normally excluded unless modified before disposal or during disposal so the operational or post closure safety of the waste cell and facility is not compromised.*
[2] ✓ = accepted, × = not accepted. ×[1]= normally excluded but possibly suitable[3]
[3] Classification of Radioactive Waste – ARPANSA RPS20

Radioactive waste classification

The Facility would be a world's best practice facility for the storage (retrievable) and permanent isolation (non-retrievable) of chemical waste. However, some wastes also contain levels of naturally occurring radioactive material.

Almost everything in nature has some small amount of natural radioactivity and processing concentrates it. At Sandy Ridge the acceptance criteria identify NORM up to Low Level Waste (LLW) activity content[3] and other LLW such as medical isotopes, smoke detectors, sealed gauges as suitable for storage and disposal in accordance with the safety case (see Table 1-3).

[2] *Classification of Radioactive Waste – RPS20, ARPANSA*

Table 1-3 NORM and LLR wastes accepted on site (surface) and below ground in waste cells

Radioactive wastes[2] (✓ = accepted, × = not accepted)	Accepted on site (surface storage)	Accepted below ground in waste cells
Naturally Occurring Radioactive Material (NORM) ***up to LLW activity levels*** *such as oil and gas industry scale*	✓	✓
Low level Waste (LLW) *such as smoke detectors, exit signs, industrial gauges and medical isotopes*	✓	✓
Intermediate level (ILW) and high level waste (ILW) *such as reprocessed spent nuclear fuel and components with high levels of radioactivity*	×	×
Nuclear waste *from power generation and defense use*	×	×

[1] *Classification of Radioactive Waste – ARPANSA RPS20*

Nuclear waste storage or disposal services would not be provided at the proposed Sandy Ridge Facility. The Sandy Ridge Project has not been nominated as a potential National Radioactive Waste Management Facility. No such nomination is planned and no such nomination would be accepted should it be made by any other party.

Radioactive waste generated in Australia generally falls within the very short lived waste (VSLW), very low level waste (VLLW), and LLW or intermediate level waste (ILW) classifications.

The Australian classification scheme for disposal of radioactive waste is based on the safety of disposal pathways, taking into account the radioactivity level and the time it would take for the radioactivity to decay (its half-life).

As such, it does not include quantitative values of allowable activity content for each significant radionuclide. Radioactive waste classification within Australia is described in Figure 1-2.

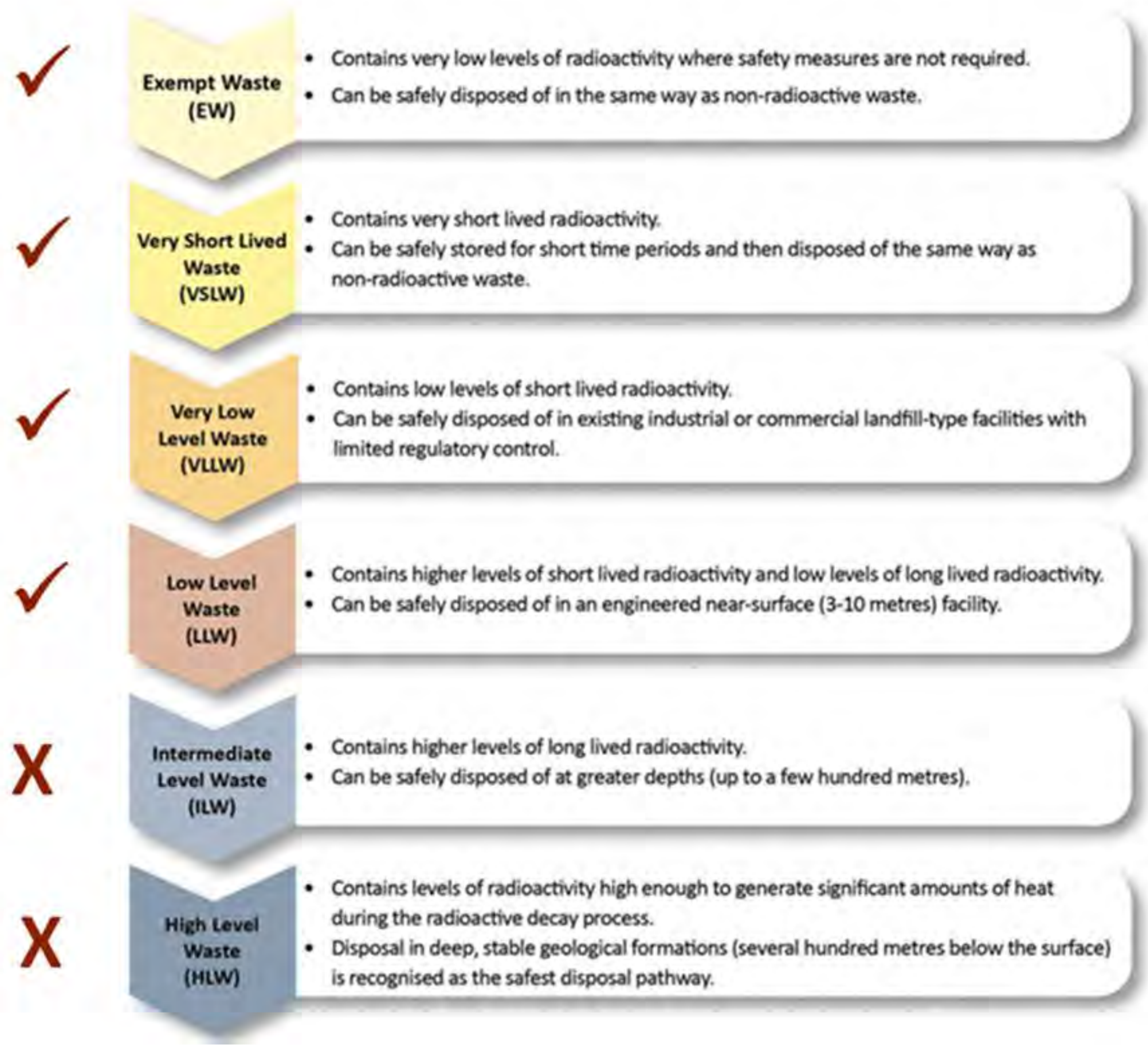


Figure 1-2 Radioactive waste classification

All wastes would be securely stored or isolated by taking advantage of the location’s natural geologically thick, flat and extensive kaolin barrier. This includes an extensive kaolin bed (kaolinised granite), approximately 70 million years old.

The kaolin and overlying silcrete layer are laterally extensive at approximately 160 km long and approximately 20 km wide and flat. The weathering profile is approximately 40 m to 50 m deep and, there is no credible risk of water ingress or contamination leaving the site (see Section 9.2.9 for more information).

1.2.4 Key characteristics of the Proposal

In accordance with *Environmental Assessment Guideline for Defining the Key Characteristics of a Proposal (EAG1)* (Environmental Protection Agency [EPA], 2012), the key characteristics of the Proposal are defined in Table 1-2.

Table 1-4 Key characteristics of the Proposal

Summary of the Proposal		
Proposal title	Sandy Ridge Facility.	
Proponent name	Tellus Holdings Ltd.	
Short description	The Proposal is to develop a kaolin open cut mine and use the voids resulting from mining for the secure storage and isolation of hazardous, intractable waste and LLW using an international best practice storage and isolation safety case. The Proposal is located approximately 75 km north-east of Koolyanobbing, WA (Figure 1-1).	
PHYSICAL ELEMENTS		
Element	**Location**	**Proposed Extent Authorised**
Pits/Cells	Figure 1-3	Clearing no more than 202.3 hectares (ha) within 1004.2 ha proposed development envelope.
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Water pipeline	Figure 5-1	Clearing no more than 27.6 ha within 1004.2 ha proposed development envelope.
Total disturbed area		Clearing no more than 276.05 ha within 1004.2 ha proposed development envelope.
OPERATIONAL ELEMENTS		
Element	**Location**	**Proposed Extent Authorised**
Ore Processing	Kaolin Plant, Figure 1-3, coordinates: 220800mE, 6637520mN	Processing of no more than 290,000 tpa of ore.
Class IV and Class V waste disposal	Pits/Cells, Figure 1-3 coordinates: 219920mE, 6638195mN	Disposal of no more than 100,000 tpa[4] Average amount per annum 66,000 tonnes (t) Maximum amount disposed 2,500,000 t over a 25 year period.
Class II Landfill for waste generated on the site	Class II Landfill, Figure 1-3 coordinates: 218507mE, 6637370mN	Disposal of no more than 500 tpa.
Water Use	Water Tanks, coordinates: 220770mE, 6637430mN	0.18 gigalitres per annum sourced from water tanks onsite that are supplied via a water pipeline from the Polaris/Mineral Resources Carina Iron Ore Mine.

[4] *The exact volumes of hazardous and LLW wastes can not be defined at this stage of project development. Subject to planning approval, there would be more certainty with respect to potential waste volumes.*

1.3 Proposal location

The Proposal is located approximately 75 km north-east of Koolyanobbing, in the Shire of Coolgardie, within the Goldfields Region of WA (refer to Figure 1-1).

The 'proposed development envelope', defined as the maximum area of ground disturbed during both construction and operation of the Proposal, is shown on Figure 1-3. The proposed development envelope would be accessed from the Great Eastern Highway via:

- A 95 km length of road to the Mount Walton East Intractable Waste Disposal Facility (IWDF) (Crown Reserve No. 44102), commonly known as the 'IWDF Access Road', that extends northward from Great Eastern Highway.
- A 4.5 km length of private road (commonly known as Mount Dimer Road) that travels west to join the IWDF Access Road.
- 5.3 km of new road that would be constructed in a northwards direction from Mount Dimer Road into the proposed development envelope (refer to Figure 1-4).

The location of the proposed development envelope was specifically chosen for its natural characteristics that meet the requirement for a near surface geological repository for hazardous intractable waste. These include:

- Quality kaolin mineral resource.
- Semi-arid climate.
- Geologically stable.
- Natural geological barriers.
- No regional aquifer.
- No surface water receptors.
- No flooding.
- Low erosion rates.
- No heritage values.
- Flat topography.

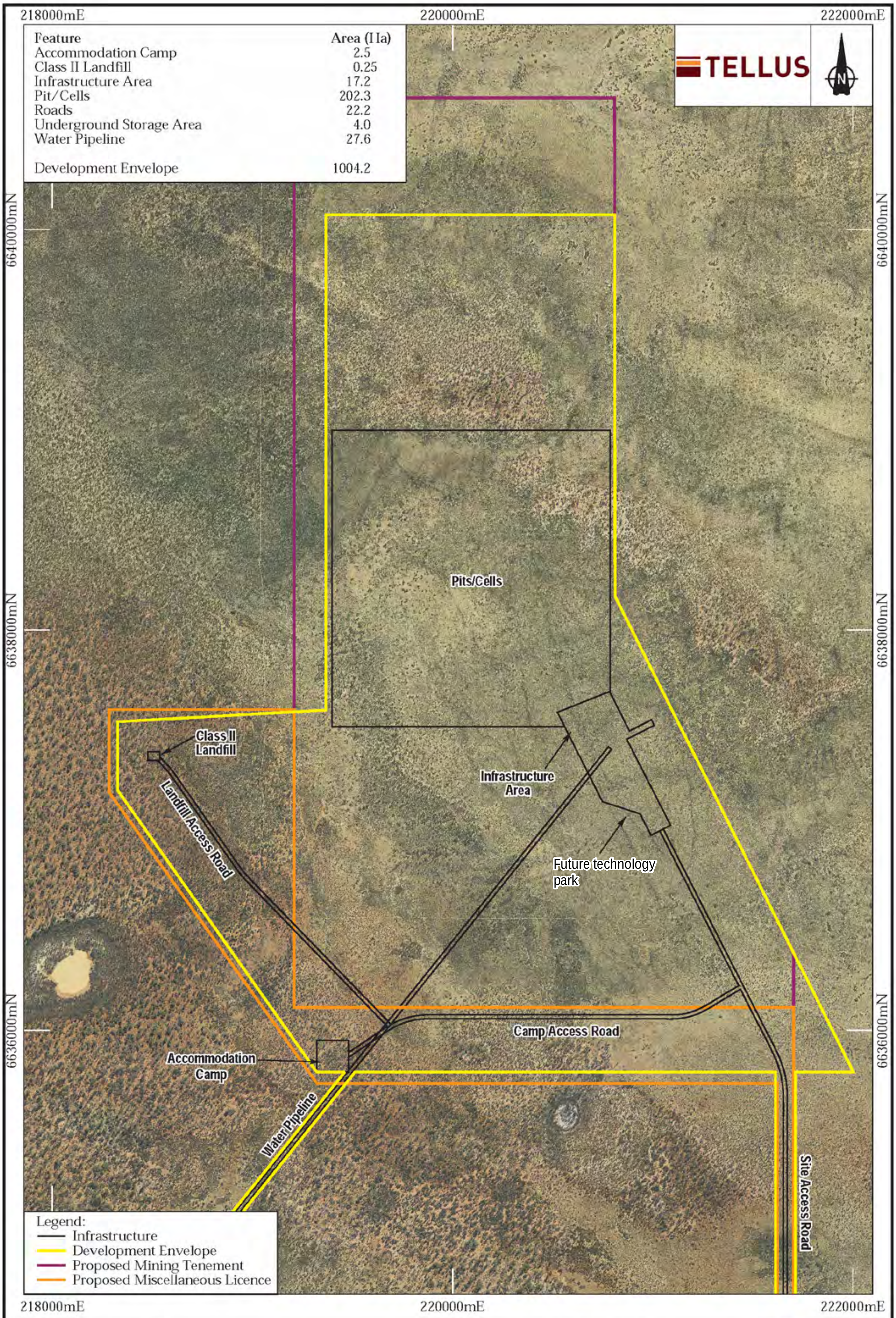
Site characteristics satisfy the International Atomic Energy Association (IAEA) requirements for a near surface geological repository for intractable and hazardous waste storage, recovery and isolation purposes.

There are no sensitive receptors within 5 km of the proposed Facility. The location of the Proposal is remote. The nearest neighbour to the proposed development envelope is the Mount Walton East IWDF Camp (approximately 6 km to the east), which is only temporarily operational during disposal campaigns and has no permanent residents.

The nearest permanent residents are located at the Carina Iron Ore Mine Accommodation Village (approximately 52 km to the south). These residents are only permanent while the mine is operational; the mine life was estimated to be 10 years in 2010 (Polaris Metals NL, 2010).

The proposed development envelope is on Crown land. It is not regarded as having any current or future value for mining (of minerals other than kaolin), nor is it regarded as valuable for agricultural or cultural purposes.

The arid and remote nature of the location, absence of a nearby population, and site characteristics (discussed further in Section 2.3) make the proposed development envelope ideal for the long term storage and permanent isolation of intractable, hazardous and low-level radioactive waste.



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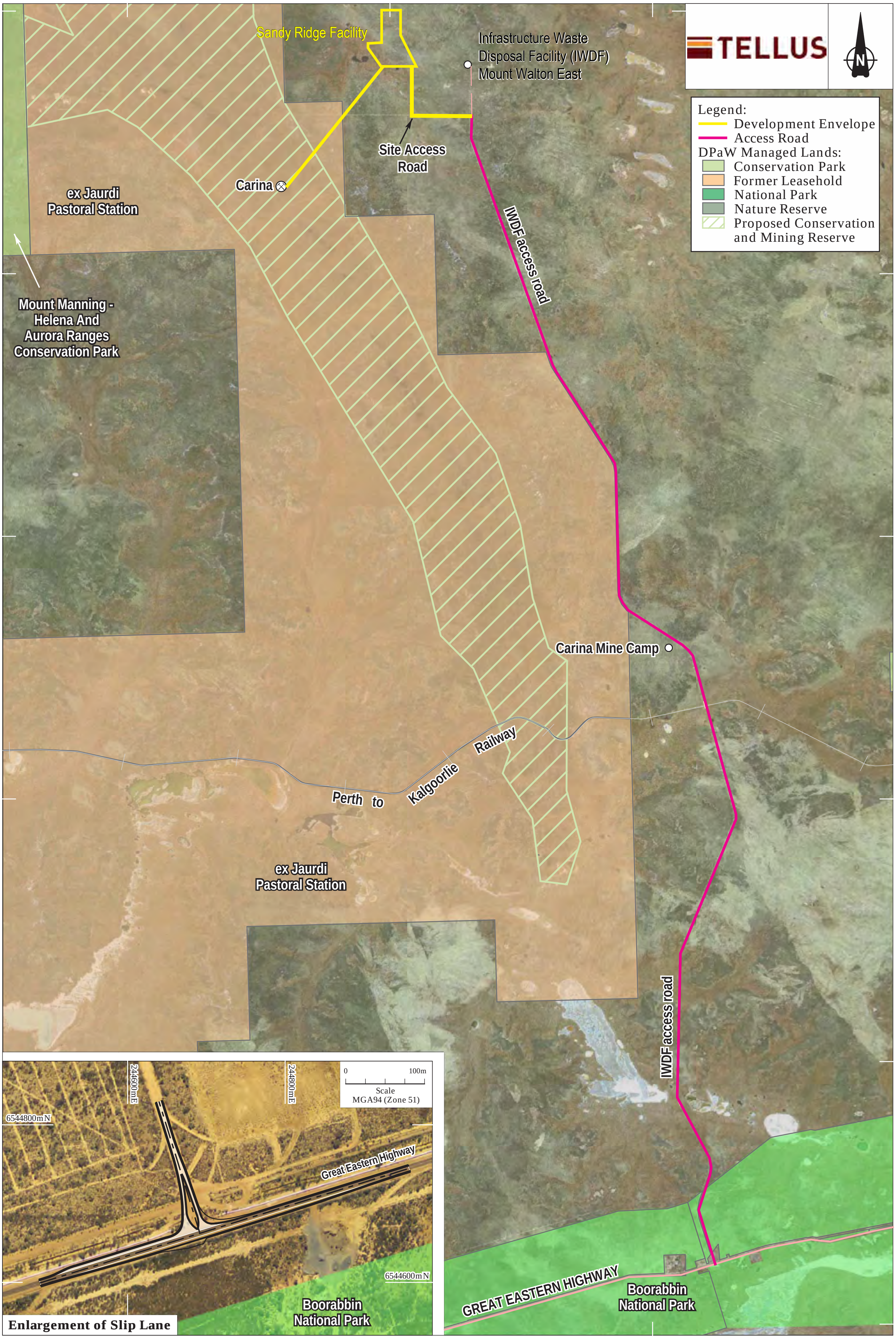
MGA94 (Zone 51)
CAD Ref: g2294_PER_01_02.dgn
Date: November 2016 | Rev: G | A4

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

Sandy Ridge Facility
Proposed development envelope
Public Environmental Review

Figure:
1-3



0 5km Scale 1:400,000 MGA94 (Zone 51) CAD Ref: g2294_PER_01_03.dgn Date: November 2016 Rev:1 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 Facility** **Access to Sandy Ridge** **Public Environmental Review**	Figure: **1-4**

1.4 The proponent

The proponent is an infrastructure development company in the business of creating economic, social and environmental value from waste, clay and salt resources. This dual revenue model involves mining the commodities kaolin clay and rock salt in thick dry remote beds which creates world's best practice geological repositories. The voids created by mining are then used to store equipment, archives or waste using a multi barrier system as part of an overall safety case.

The proponent plans to permanently isolate hazardous waste using environmentally sound management principles that protect the environment and human health. The proponent also supports the circular economy using long term storage by placing like-with-like materials for operational safety reasons and to create opportunities for the future recovery of valuable materials. The proponent' business model mirrors international solutions operating in the United Kingdom, Europe and North America. The proponent is developing the proposed Sandy Ridge Facility in WA and the proposed Chandler Facility in the Northern Territory (NT) which has been awarded Major Project Status by the NT Government.

The company details are as follows:

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Suite 2, Level 10
151 Castlereagh Street
Sydney NSW 2000
Tel: +61 2 8257 3395
ABN 97 138 119 829

The key contact for the Proposal is:

Mr Richard Phillips
Environment and Approvals Manager
Suite 2, Level 10
151 Castlereagh Street
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Tel: +61 2 8257 3395
Email: info@tellusholdings.com

1.5 Environmental record of the proponent

The proponent incorporated in 2009 and has offices and two proposals currently undergoing environmental assessment and planning approvals. The first at Sandt Ridge in WA and the second at Chandler in the Northern Territory. The proponent is not currently, nor has the company ever been, subject to any proceedings under a Commonwealth, State or Territory law in relation to the protection of the environment or the conservation and sustainable use of natural resources.

1.6 Overview of this Public Environmental Review

The purpose of the PER is to support approval for the Proposal under the EP Act and the EPBC Act (Cth). The PER has been prepared to address the requirements set out in the ESD that was accepted by the WA OEPA on 27 May 2016 under Part IV of the EP Act.

1.6.1 PER objectives

The objectives of the PER, and reference to these objectives within the document, are listed in Table 1-3.

Table 1-5 Objectives of the PER

No.	Description	Document reference
1	Place this Proposal in the context of the local and regional environment.	Section 1.3 and Chapter 9
2	Adequately describe all components of the Proposal, so that the Minister for Environment (State and Federal) can consider approval of a well-defined Proposal.	Chapter 5
3	Provide the basis of the Proponent's environmental management program, which shows that the environmental impacts resulting from the Proposal, including cumulative impact, are minimised and can be acceptably managed.	Chapter 12
4	Communicate clearly with stakeholders (including the public and government agencies), so that the EPA can obtain informed comment to assist in providing advice to government.	Chapter 6
5	Provide a document which clearly sets out the reasons why the Proposal should be judged by the EPA and the Minister for Environment (State and Federal) to be environmentally acceptable.	Chapter 13

1.6.2 Report structure

This PER is presented in the following chapters:

Chapter 1: **Introduction** – this chapter introduces the Proposal, the proponent and location of the Proposal. The purpose, scope, objectives and structure of the document are described. The location of information required by Schedule 4 of Environment Protection and Biodiversity Conservation Regulations 2000 is described.

Chapter 2: **Proposal Alternatives, Justification and Benefits** – this chapter outlines the alternative options considered and the justification for the Proposal. The potential benefits to WA and Australia are also outlined in this chapter.

Chapter 3: **Environmental Assessment Process** – this chapter describes the State and Commonwealth environmental assessment processes and the status of approvals for the Proposal.

Chapter 4: **Legislative Framework** – this chapter provides an overview of the environmental approvals required for the Proposal. A list of the relevant environmental legislation, regulations, conventions, treaties, policies, guidelines and code of practices that are relevant to the implementation of the Proposal is provided.

Chapter 5: **Proposal Definition** – this chapter provides a comprehensive description of the Proposal. Construction and operation of the Proposal is also discussed.

Chapter 6: **Stakeholder Consultation and Engagement** – this chapter documents the stakeholder engagement and consultation program undertaken by The proponent during the preparation of the ESD and PER. The focus of engagement was to seek feedback from key decision making authorities and stakeholders with respect to the potential environmental and social aspects that a) should be considered during the environmental impact assessment process and b) addressed in the PER.

Chapter 7: **Environmental Factors and Principles** – this chapter lists the key environmental factors outlined in the ESD. A discussion of the application of the EPA's *Environmental Assessment Guideline for Environmental Principles, Factors and Objectives* is also provided.

Chapter 8: **Environmental Risk Assessment** – this chapter provides a risk assessment of the potential environmental impacts associated with construction and operation of the Proposal.

Chapter 9: **Existing Environment** - This chapter describes the existing environment of the proposed development envelope (and vicinity) for each of the key environmental factors outlined in the ESD.

Chapter 10: **Assessment of Key Environmental Factors** – this chapter describes the existing environment of the proposed development envelope and provides an environmental impact assessment for each of the key environmental factors outlined in the ESD. For each key environmental factor, proposed mitigation/management measures to avoid or reduce potential impacts are provided. The predicted environmental outcome is provided for each key environmental factor assessed.

Chapter 11 **Assessment of Other Environmental Factors** – this chapter assesses other environmental factors considered relevant to the Proposal. These environmental factors include amenity (in relation to noise, dust and visual impacts) as well as the water source and viability of the water source for the Proposal. Cumulative impacts are assessed, as is the controlled nuclear action.

Chapter 12 **Management Framework** – this chapter outlines the environmental management program that would be implemented during both construction and operation of the Proposal. This chapter provides a commitment to the continued protection of the environment.

Chapter 13: **Justification and Conclusion** – this chapter provides the justification for the Proposal and concludes the assessment of key environmental factors and the environmental assessment process for the Proposal.

Chapter 14: **PER Technical Team** – this chapter provides a list of the team involved in the preparation of the PER.

Chapter 15: **References** – this chapter provides references for scientific statements made in the PER.

The appendices are labelled with the prefix 'A' and are located in Volume VI.

2 PROPOSAL ALTERNATIVES, JUSTIFICATION AND BENEFITS

2.1 Introduction

The following Proposal alternatives were considered during the development of the conceptual design:

- Not proceeding with the Proposal (the 'do nothing' scenario).
- Site selection.
- Site selection for mining components.
- The preferred approach to mining the kaolin.
- Access to the site.
- Transporting kaolin.
- Water supply.
- Power supply.
- Mining spoil.
- Design of waste cells.
- The types of waste to be accepted and criteria for accepting them.
- The handling and storage of wastes.

Further discussion of these alternatives is presented in Section 2.2. Section 2.3 presents background information on why Sandy Ridge was the proponent's preferred location for the Proposal.

2.2 Alternative options

Alternative options were investigated using the following hierarchy (prescribed by EPA, 2012) that moves from broad/strategic to increasingly narrow/Proposal specific in nature.

1) The consequences of not proceeding with the Proposal

The consequences of not proceeding with the Proposal would mean that the associated economic and environmental benefits would not be achieved or realised. Not proceeding with the Proposal would result in the following:

- Based on a maximum 40,000 tonnes per annum kaolin processing plant design, up to 1,000,000 tonnes per annum of kaolin export to Asia and the domestic market would not be produced.
- Up to 2,500,000 tonnes of hazardous wastes over 25 years would be either exported overseas or stored inappropriately in locations across Australia, awaiting an appropriate long-term storage solution.
- Loss of significant capital expenditure during construction of the mine worth $61.4 million.
- Loss of expenditure during operation of the mine worth $828 million

- Loss of 90 construction jobs including indirect jobs.
- Loss of 25 full time equivalent operational jobs.
- Loss of business opportunities for local and regional suppliers.
- Loss of royalties over and taxes the life of the Proposal to the Commonwealth and WA governments.
- Loss of enabling infrastructure that provides cost competitive worlds best practice waste solutions to the mining, oil & gas, manufacturing industries and government for some of their most difficult to manage wastes that would otherwise meet their national and international obligations.
- Loss of infrastructure that can provide long term storage, or permanent isolation services that minimise adverse impacts of the hazardous waste on the environment and human health.
- Loss of infrastructure that could support the recovery of valuable materials back into the circular economy.

2) Need/meeting needs – is this development needed? Consider no-action alternative.

Post the proponent's successful drilling program (265 holes, 7,938m), maiden JORC resource, 35 t bulk pilot project that produced 9 tonne of saleable kaolin for the target ceramic and paint market, market development in the growing Asian market Tellus has already signed a kaolin market development agreement with a specialist kaolin trading house based in Hong Kong. Currently, WA has no operating kaolin mines. Tellus' market analysis indicates a strong demand for Tellus'kaolin in the Asian marketplace for the life of mine (25 years).

The proponent also considers the demand for storage, recovery and isolation of hazardous and intractable wastes a necessity in WA. At present, WA has one operational Class IV facility (Red Hill Waste Management Facility) and one campaign based operational Class V facility (IWDF) that was last open eight years ago.

The proponent market research and review of relevant government reports indicates that Australians are the second highest emitters of hazardous waste per capita due to our economy being driven largely by mining, oil and gas, and manufacturing and a growing industrialised population. A forward looking hazardous waste production profile (5.5 M tpa) continues to grow at about 3% per annum. A large 900 million tonne legacy 'waste pile continues to grow not only from the current 'resources boom' but from previous booms and busts are awaiting cost effective and permanent solutions.

The use of existing facilities, such as the IWDF facility, is limited for the following reasons:

- The site is cost prohibitive.
- It is complex for customers, as the onus is on waste producers to demonstrate that they have exhausted all other potential options for handling the waste materials before they can be directed to the IWDF.
- The site is only open for a campaign style operation once every few years, with the last operation in 2008.

This does not match the requirements of most customers, who want to do the right thing within a reasonable cost structure and timeframe.

The consequences of not proceeding with the Proposal are that no commercially viable alternative to the IWDF is available to waste owners. Without the Proposal, the community and environment would potentially remain at risk from the unsafe and unsecure storage of hazardous and intractable waste, or would have to be shipped overseas, at great risk and cost to international facilities.

The Proposal has the potential to deliver economic, environmental and social benefits. These potential benefits are discussed in more detail in Section 2.5. If the Proposal were not to proceed, the potential benefits documented in this PER may not be achieved; therefore, the no action alternative is not considered feasible.

The proponent' prefeasibility study included the option of not proceeding. That option was eliminated as there is a demonstrated demand from customers for the dual revenue business.

3) Mode/meeting general goals – is this development proposal the best way to meet the general goal? Consider alternative technologies or options.

Planning of the proposed Sandy Ridge Facility commenced in 2012. The exploration tenement was granted in 2013 and detailed desktop studies were completed. In 2014, exploration commenced and the Sandy Ridge Scoping Study commenced (Tellus, 2014) was completed to a Front End Loading (FEL 1) standard.

Thirteen independent companies contributed to the study from three countries. Nine options were studied for the business case (Table 2-1). The selected base case (i.e. Option 1) demonstrated the Proposal to be technically feasible and economically viable, and to have robust economics and no fatal flaws.

Table 2-1 Nine potential options for base business case

Scenario	Option 1 dry 20ktpa	Option 2 dry 40ktpa	Option 3 dry 80ktpa	Option 4 dry 160ktpa	Option 5 dry 200ktpa	Option 6 40ktpa	Option 7 wet 40ktpa	Option 8 wet 80ktpa	Option 9 50ktpa waste only
Volume kaolin	20ktpa	40ktpa	80ktpa	160ktpa	200ktpa	40ktpa	40ktpa	80ktpa	None
Volume waste	50ktpa	50ktpa	50ktpa	50ktpa	50ktpa	50ktpa	50ktpa	50ktpa	50ktpa
Kaolin processing	Dry	Dry	Dry	Dry	Dry	Calcin Plant	Water washed	Water washed	None
Kaolin products	2	2	2	2	2	4	2	2	None

The pre-feasibility phase (FEL 2) followed the Scoping Study, during which a range of design and operational options for the proposed Sandy Ridge Facility were considered. A summary of the alternative options considered is provided in Table 2-2.
The net result of the scenarios analysed and the base case selected allowed detailed feasibility studies to be completed that confirmed the selected base case project configuration was technical and commercially feasible and had no fatal flaws, plus extensive commercial negoatiations demonstrated demand for a dual use kaolin mine and an arid near surface storage, recovery and permanent isolation facility to serve WA and Australia.

By combining a kaolin mine and waste repository into a single project, in an environmentally and geologically optimum location, these technical and safety case demands would be satisfied while producing a commercially viable service offering that gives our customers confidence to sign long term agreements.

Table 2-2 Alternative options considered

Proposal element	Options considered	Option chosen	Reason
Mining method	Open cut	Open cut	Open cut mining is accepted as best practice for the kaolin industry. An alternative mining method is not considered feasible, particularly in a remote location that is not constrained by sensitive environmental receptors. The mining footprint is also conducive to open cut, as it has a small surface area and the ore is relatively close to the surface (within 30 m).
Kaolin processing	Dry method or wet method	Wet method	Dry processing was not the chosen method because: • Dry processing trials demonstrated that the mass recovery of kaolin from the quartz gangue was lower than expected (uneconomical), and there was significant carry-over of very fine quartz particles into the kaolin product (resulting in a poor quality product). • Dry processing trials indicated that abrasive wear rates on the process machinery would be high, resulting in unacceptable maintenance costs and contamination of the product (with worn metal). • The original target market was a lower specification general ceramics product grade. In order to achieve an acceptable sale price, it is necessary to produce a finer particle size product which cannot be done at acceptable recoveries using dry separation methods. Wet processing methods provide higher product recoveries with less quartz contamination, do not have high machine wear rates, and are capable of separating at very fine particle sizes with acceptable recoveries. Therefore, the wet processing method was chosen.
Waste storage	Commonly accepted options: • Near surface repository (at ground level, or in caverns below ground level (at depths of tens of metres)	Arid near surface repository	The site characteristics (refer to Section 2.3) are conducive to a near surface repository. A deep geological repository is not considered feasible at Sandy Ridge due to:

Proposal element	Options considered	Option chosen	Reason
	• Deep geological repository (at depths of between 250 m and 1000 m for mined repositories or between 2000 m and 5000 m for boreholes). Other options considered worldwide (WNA,* 2015a): • Long-term above ground storage. • Disposal in outer space. • Rock-melting. • Disposal/permanent isolation at subduction zones. • Sea disposal. • Sub seabed disposal. • Disposal/permanent isolation in ice sheets. • Direct injection.		• Drilling and excavation of the granite bedrock being expensive and time consuming. • Generally deep geological repositories are used for disposal of high level long-lived radioactive waste. Intermediate and high level long-lived radioactive waste would not be accepted at Sandy Ridge. Other options used worldwide are for disposal of radioactive wastes only, not chemical wastes. Therefore, these options are not considered appropriate to dispose of chemical wastes.
Source of water	• Carina Iron Ore Mine pit water. • Production bore in paleo-channel. • Importing water.	Carina Iron Ore Mine pit water.	Based on extensive drilling and groundwater monitoring results, the proposed development envelope lacks a true water source. Therefore, the nearest available water source was the Carina Pit water located approximately 12 km south-west. Easy access to the mine pit and water resource, and relatively cheap costs to obtain the water, were the key factors in selecting the Carina Pit water source.

4) Location/meeting project objectives spatially – what is the best location for the project. Consider alternative locations with a view to minimising environmental impacts.

Favourable environmental factors within the proposed development envelope were the principal reasons for the preferred location as they met the requirements for a dual use kaolin mine (quality grade kaolin) and near surface geological repository for intractable and hazardous waste storage, recovery and isolation purposes. The environmental factors are the evidence that supports the safety case showing that waste can be safely isolated from the biosphere for the long term.

As outlined in Section 2.3 below, the environmental setting of the proposed development envelope also meets the siting criteria for near surface permanent isolation of radioactive waste.

The IWDF is approximately 7 km east of the proposed Sandy Ridge Facility, and the IWDF was chosen by government and approved previously by the EPA for its suitable environmental setting. The IWDF has operated since 1991 without environmental incident, groundwater monitoring has never detected groundwater, and subsidence has been minimal.

The proponent holds an exploration licence (E16/440) over the land and has explored the area since tenement grant in January 2013. Exploration drilling has outlined a Joint Ore Reserves Committee (JORC) Inferred Mineral Resource of 17.6 million tonnes of kaolinite[5], with 9.5 million tonnes classified as ceramic grade and 8.1 million tonnes classified as paint grade. A 17.6 million tonne resource is likely to provide sufficient ore for a lot longer than the proposed 25 year mine life. The clay bed is thick, flat, continuous, easy to mine and scalable.

The proponent does not currently hold any other granted exploration licences or mining leases in WA. Therefore, no other location is available to The proponent for the establishment of a mine.

5) Timing/meeting project objectives temporally – what is the best sequence of development for components of the project?

The long-term mine life (25 years) and need to store wastes in perpetuity means an alternative timeframe for the Proposal does not apply. For financial evaluation purposes the Proposal assumes a mine life of only 25 years. Given the abundance of kaolin mostly for export and the immediate need for an operating near surface geological repository, no alternative timeframe is considered feasible.

6) Implementation mechanisms/designing project – What is the best way to optimise the project so as to minimise environmental impacts? Consider detailed site design, layout, technologies and mitigation strategies.

The proposed development envelope has been purposely chosen to minimise potential adverse impacts on the environment from construction and operation of the long-term permanent storage of hazardous and intractable waste. The proposed development envelope is not constrained by potentially significant environmental and social sensitivities such as:

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[5] *Refer to Tellus Media Release 19 June 2014 Sandy Ridge – JORC Resource Estimation (www.tellusholdings.com.au)*

- Schools, hospitals or communities.
- Cultural heritage.
- Groundwater.
- Surface water (rivers or streams).
- Threatened flora and fauna.

As the elements of the operation are progressed to detailed design, the proponent would continue to aim for best practice in site design, technologies and mitigation strategies to avoid and minimise environmental impacts. An example of this is the commissioning of surface water hydraulic analysis, which overestimates surface water flows across the proposed development envelope. This was done to ensure the proponent has adequate surface water management in place for 72 hours, 1 in 2000 year flood events.

2.3 Why the Sandy Ridge site?

The following international and national codes outline the major site selection factors for near surface geological repositories:

- *Practical Sourcebook on Mercury Waste Storage and Disposal,* (United Nations Environment Programme [UNEP] *et al.*[6], 2015).
- *Licensing of Radioactive Waste Storage and Disposal Facilities* (Australian Radiation Protection and Nuclear Safety Agency [ARPANSA], March 2013).
- *Department of Treasury and Finance, 2011, Disposal of Chemical wastes at the Intractable Waste Disposal Facility (mount Walton East) – Waste Acceptance Guidelines.*
- *Classification and Disposal of Radioactive Waste in Australia – Consideration for Near Surface Burial in an Arid Area* Technical Report 152, (ARPANSA, 2010).
- *Considerations in the Development of Near Surface Repositories for Radioactive Waste* (International Atomic Energy Agency [IAEA] Technical Reports Series 417, 2003).
- *Code of Practice for the near-surface disposal of radioactive waste in Australia* (National Health and Medical Research Council [NHMRC], 1992). Site selection factors listed in this code are detailed in Table 2-3.

'Near surface disposal' means the disposal of radioactive waste in structures located approximately 30 metres below and/or above the natural ground surface and covered by a layer(s) of natural and/or manufactured materials (NHMRC, 1992).

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[6] *The United Nations Environment Programme (UNEP) Governing Council, in decision 25/5, requested UNEP to enhance capacity for mercury storage and provide information on the sound management of mercury and mercury wastes. The project for the preparation of this report is one of UNEP's responses to this request. The project is a joint initiative of UNEP Chemicals Branch, Division of Technology Industry and Economics, UNEPs International Environmental Technology Centre, and the International Solid Waste Association (ISWA) under the UNEP Global Mercury Partnership.*

Consultation with ARPANSA and the Radiation Health Branch of the WA Department of Health has indicated that the *Code of Practice for the near-surface disposal of radioactive waste in Australia* (NHMRC, 1992) is the applicable code for the establishment of a near surface geological repository in WA. Table 2-3 lists the reasons the Sandy Ridge site meets the site selection criteria outlined in this code. These site characteristics include:

- **Geologically stable** — the development envelope sits within the Archean Yilgarn Block and is geologically typical of areas overlying deeply weathered granite domes. It has very low seismicity (no earthquakes have been recorded at Sandy Ridge) and no volcanic or tectonic activity.
- **Natural geological barrier** — the clay bed is laterally extensive (approximately 16 km long and 40 km wide), has been stable for approximately 70 million years and is up to 36 m thick. This is capped by erosion resistant impermeable silcrete and laterite layers typically 4 to 6 metres thick in total.
- **Semi-arid desert Mediterranean climate** — averages just over 250 mm of rainfall per annum and evaporation is greater than 2,000 mm per annum. This means very little rainfall occurs across the site and generally water will evaporate before it infiltrates.
- **No surface water receptors** - there are no channels or creeks in the development envelope.
- **Very little (if any) surface water runoff** – Due to the low rainfall, high evaporation, permeable upper soil profile and gently sloping topography, significant rainfall events infiltrate quickly. There is a low likelihood of surface flows in the local catchments and any flows are short-lived and local in nature.
- **Lack of commercial mineral deposits** – there is no evidence to suggest that there is potential for economic mineral or hydrocarbon deposits beneath the kaolin deposit.
- **Topography** – the development envelope is flat to gently undulating and suitable for the construction of infrastructure and heavy vehicle movement.
- **Absence of Population** – located in an area with no population, the nearest population centre is a non-permanent camp approximately 52 km away.
- **Agricultural land use** – there is no potential for medium to high value agriculture.
- **Environmental values** – the environmental values of the development envelope have been investigated through baseline environmental surveys. Baseline environmental conditions are detailed in Chapter 9. In summary, environmental values applicable to the proposed site include Diverse Eucalyptus woodlands, grasslands, yellow and red sandplains and gravelly sandplains. The proposed development envelope is located in the Southern Cross IBRA subregion which supports a diverse range of terrestrial fauna. The proposed development envelope lacks significant surface and ground water features. Notable climatic conditions include very low average annual rainfall and very high evaporation rates.
- **Heritage** – no special cultural or historical significance has been identified through a completed heritage study and consultation with stakeholders familiar with the area.

- **No flooding** – the development envelope is not subject to flooding, nor is it predicted to be in the future. The site is at very low risk of encountering cyclones.
- **Very low rates of erosion** – the development envelope is not subject to the erosive forces of high winds or rain due to the climate, soil types and topography and has been stable for thousands of years.

As outlined in Table 2-3, the proposed development envelope meets all the NHMRC (1992) site selection criteria and is an ideal location for a near surface geological repository.

Table 2-3 Proposed development envelope characteristics that meet *Code of Practice for the near-surface disposal of radioactive waste in Australia* criteria

Criteria (extracted from NHMRC, 1992)		Proposed development envelope characteristics
a	The Facility site should be located in an area of low rainfall, should be free from flooding and have good surface drainage features, and generally be stable with respect to its geomorphology.	The proposed development envelope averages just over 250 mm of rainfall per annum and evaporation is greater than 2,000 mm per annum (BoM, 2015a). This means very little rainfall occurs across the proposed development envelope and generally water would evaporate before it infiltrates. The proposed development envelope is not subject to flooding, nor is it predicted to be in the future. The site is at very low risk of encountering cyclones. There are no defined surface watercourses or water bodies in the proposed development envelope. The proposed development envelope is located close to the top of a watershed which means that catchment areas for surface water flows are small. The proposed development envelope sits within the Archean Yilgarn Block and is geologically typical of areas overlying deeply weathered granite domes. Landforms within the proposed development envelope have been in place for about 250 million years. It is a combination of a virtually flat plateau, cemented surface layers, and semi-arid conditions that creates the stable geomorphology of the area (CRM, ˜ 2016).
b	The water table in the area should be at sufficient depth below the planned disposal structures to ensure that groundwater is unlikely to rise within five metres of the waste, and the hydrogeological setting should be such that large fluctuations in the water table are unlikely.	Hydrogeological investigation of the proposed development envelope confirms no regional aquifer is present. This is consistent with findings at the nearby IWDF, as no groundwater has been detected in monitoring bores since monitoring began in 1995 (Department of Finance, 2014). This confirms that the absence of groundwater is a regional phenomenon within the extensive kaolinite deposit. See Section 10.5 for further information on the hydrogeology of the proposed development envelope.
c	The geological structure and hydrogeological conditions should permit modelling of groundwater gradients and movement, and enable prediction of radionuclide migration times and patterns.	The top of the clays and the base of the surface layer of permeable soils are delineated by a thick layer of highly impermeable silcrete which acts to limit vertical migration of groundwater or infiltrating surface water. The silcrete layer and very high available climatic energy ensures that even very large rainfall events are contained within the top few metres of ground, and are subsequently evaporated before the water can infiltrate to create an aquifer.
d	The disposal site should be located away from known or anticipated seismic, tectonic or volcanic activity which could compromise the stability of the disposal structures and the integrity of the waste.	The proposed development envelope is within an area with the lowest hazard rating for earthquakes in Australia. This means there is a very low risk of earthquakes affecting the structural stability of the waste cells. The proposed development envelope is situated on the Archaean Yilgarn Shield, within the central portion of the eastern section of the Indo-Australian Plate. This eastern section is, in general, moving at around 5.6 cm per year

	Criteria (extracted from NHMRC, 1992)	Proposed development envelope characteristics
		towards the north-east (Hammonds, 2012). This rate of movement and the location of the proposed development envelope within a seismically quiet portion of a stable shield is very unlikely to cause any significant tectonic activity (uplift, subsidence, or fracturing) in any timeframe relevant to the Proposal (CRM, 2016). There has not been any igneous activity in the region for over 1,000 million years. There is no reason to expect that there would be any sub-surface or surface volcanic activity within this part of the stable craton for at least 50 million years (CRM, 2016).
e	The site should be in an area of low population density and in which the projected population growth or the prospects for future development are also very low.	The proposed development envelope is located in an area with no population; the nearest population centre is a non-permanent camp approximately 52 km away. The nearest town (Koolyanobbing) is 75 km away. The proposed accommodation camp would be located at least 3 km from the proposed operational Sandy Ridge site. Owing to the isolated location of the Proposal, there is no projected future development at either the proposed accommodation village or surrounding the Sandy Ridge site.
f	The groundwater in the region of the site which may be affected by the presence of a Facility should ideally not be suitable for human consumption, pastoral or agricultural use.	Hydrogeological investigation of the proposed development envelope confirms no regional aquifer is present. Groundwater in the region is likely to be within fractured rock aquifers at significant depths. Based on information from the Carina Iron Ore Mine, groundwater is extremely salty, and close to the concentration of sea water. It does not have any beneficial use for human, pastoral or agricultural use.
g	The site should have suitable geochemical and geotechnical properties to inhibit migration of radionuclides and to facilitate repository operations.	The storage and permanent isolation cells would be surrounded by several kilometres of competent kaolin and underlain by at a minimum thickness of 5 m of undisturbed natural kaolin. The kaolin within the proposed development envelope has an in situ permeability of the order of 1 x 10^{-7} m/s which means it would act as an aquiclude and retard the flow of water both vertically and horizontally. The Soils and Materials Characterisation report (refer to Appendix A.5) presents information on kaolin properties which confirm that it has a significant cation exchange capacity and the ability to absorb and retain cations. Whilst kaolin is not the most active clay, it still typically has a cation exchange capacity in the range 3–15 which means that it has a substantial capacity to capture and retain positively charged ions such as those associated with heavy metals and most radionuclides. This coupled with the large volume of kaolin surrounding the cells and the absence of groundwater means that there is an extremely large capacity to absorb and retain contaminants in the unlikely event that they were to leach from the storage or permanent isolation cells.

	Criteria (extracted from NHMRC, 1992)	Proposed development envelope characteristics
h	The site for the Facility should be located in a region which has no known significant natural resources, including potentially valuable mineral deposits, and which has little or no potential for agriculture or outdoor recreation use.	• There is no evidence to suggest that there is potential for economic mineral or hydrocarbon deposits beneath the kaolin deposit. The economically mineable kaolin would be recovered during the Proposal. • There is no potential for medium to high value agriculture. • The proposed development envelope is remote from towns and within a semi-arid climate, and highly unlikely to be used for outdoor recreation use.
i	The site should have reasonable access for the transportation of materials and equipment during construction and operation, and for the transport of waste into the site.	The proposed development envelope is accessible from all parts of Australia via major roads, highways and ports. The proponent is in discussions with the WA Government (Department of Finance) regarding an access agreement to use the IWDF access road and have also been discussing an easement for the IWDF access road with the Department of Lands.
j	The site should not be in an area which has special environmental attraction or appeal, which is of notable ecological significance, or which is the known habitat of rare fauna and flora.	The development does not contain any Environmentally Sensitive Areas or Matters of National Environment Significance. No rare (referred to as 'Threatened' under State and Commonwealth legislation) flora or fauna habitats have been identified within the proposed development envelope. Therefore, the proposed development envelope has no special environmental attraction or appeal.
k	The site should not be located in an area which is of special cultural or historical significance.	An aboriginal heritage survey did not record any evidence of Aboriginal heritage sites (registered or previously unrecorded) or ethnographic values in the proposed development envelope. A search of the Land, Approvals and Native Title Unit (Government of Western Australia, 2015) indicated there are no registered native title claims over the proposed development envelope. There are no world heritage, Commonwealth or national or state heritage listed places in the proposed development envelope.
l	The site should not be located in reserves containing regional services such as electricity, gas, oil or water mains.	No regional services infrastructure is located beneath the proposed development envelope.
m	The site should not be located in an area where land ownership rights or control could compromise retention of long-term control over the Facility.	The proposed development envelope is located on Crown Land.

** Bureau of Meteorology*

~ Continental Resource Management Pty Ltd

2.4 Proposal justification

The viability of the proposed Sandy Ridge Facility would rely on implementing both aspects of the dual revenue Proposal:

- The kaolin business.
- The waste storage, recovery and isolation business (in an arid, near surface geological repository).

2.4.1 Need for kaolin products

What is kaolin and what is it used for?

Kaolin is found across Australia, with large deposits in WA, but significant production is now restricted to Victoria. Kaolin is a soft white material primarily consisting of the mineral kaolinite, with varying amounts of other minerals such as halloysite and micas. Kaolinite is a hydrated aluminium silicate $Al_2Si_2O_5(OH)_4$. The chemical weathering of feldspar to kaolin within the proposed development envelope has taken place from 260 million years ago (CRM, 2016). Kaolin is formed by the chemical weathering and decomposition of rocks in hot, moist conditions. Properties of kaolin include; fine particle size, platy structure, inertness, non-toxicity, and high brightness and whiteness which make it a most versatile mineral, with applications in a wide variety of industries.

Kaolin is a necessary mineral component for a diverse range of products. Kaolin is used in the following global industries:

- Paper 35%.
- Ceramics 29%.
- Other 24%.
- Fiberglass 6%.
- Paints 6%.

Western Australian kaolin supply

WA has a number of world class kaolin deposits but none of these have been able to be developed on a commercial scale because of development and operating cost hurdles. In the case of Sandy Ridge, these economic disincentives are easier to manage due to the opportunities associated with operating a dual revenue business. In Sandy Ridge's case, it is mining kaolin and using void spaces as a near surface geological waste repository to collect two revenue streams.

The proponent wishes to service the growing Asian market on a long-term basis. By 2017, Asia is forecast to account for almost 40% of total world demand for kaolin products. The proponent is planning on exporting approximately 80% of the volume processed at Sandy Ridge to Asia principally for use in ceramic production. Other markets include paper and paint. Approximately 20% of the volume would be sold domestically in similar markets.

As a result, for the first time, WA would potentially have a viable kaolin mine, and storage Facility which would generate additional regional investment, training and jobs, business opportunities, infrastructure, royalties and taxes for the State and improved overall product stewardship. The kaolin deposit at Sandy Ridge has been determined to be high grade and Australia is well positioned geographically for the distribution of the processed kaolin products into the Asian marketplace.

Worldwide kaolin deposits

Major global kaolin deposits are located in Georgia and South Carolina in the United States of America, Cornwall in England, and in the lower Amazon basin in Brazil. Other significant deposits are located in Australia, Argentina, Czech Republic, China, France, Germany, Indonesia, Iran, Mexico, South Korea, Spain, Turkey and Ukraine (International Institute for Environment and Development and World Business Council for Sustainable Development, 2002).

Global kaolin market demand

Kaolin is the most important of the industrial clays in terms of both consumption and value. The industry is valued at US$4.4 billion with an average growth rate of approximately 2.4%. Australia has a large number of remote kaolin deposits; however, processing and infrastructure costs commercially constrain the number of operators, with only one sizeable operation currently run by a subsidiary of French multinational, Imerys. Imerys is the largest kaolin exporter and is based in Victoria. The cost of producing a small tonnage of kaolin is not viable as a single revenue business; therefore, by coupling the kaolin mining with waste storage and isolation, the proposed Facility becomes viable to construct and operate.

The Asia Pacific region continues to have the largest kaolin market influence globally, underpinned by strong manufacturing demand and continued urban development amongst its emerging economies. These trends are expected to continue and consolidate Asia as the fastest growing kaolin demand region over the next five years, hosting the top four growth users: China, India, Malaysia and Thailand.

The issue faced by Asian kaolin customers is the lack of a reliable supply of quality kaolin, which is primarily due to two factors:

- The existing kaolin mines are nearing closure, and the resource is exhausted, so the kaolin grade is lower and the cost of kaolin is more expensive
- New suppliers operating in China and Vietnam struggle to achieve a consistent quality of kaolin.

Kaolin customers are looking for long-term reliable supply of good quality kaolin. The majority of the importers of kaolin are based in Asia (Vietnam, Japan and China).

2.4.2 Need for a waste repository

The problem

Australian's are the second highest emitters of hazardous waste per capita due to our economy being driven largely by mining, oil and gas, and manufacturing. Approximately 10% of the waste Australian's produce is hazardous. That means approximately 5.5 to 6.0 million tonnes per year of known hazardous waste is produced and is growing at approximately 3% per annum. There is approximately 900 million tonnes of reported legacy waste (hazardous and intractable waste generated historically) estimated to be temporarily stored in WA and across other Australian states and territories.

The solution

There is n environmental and health and safetya need and regulatory obligation (refer to Chapter 4 for more information) to provide for the safe and secure storage and permanent isolation of both hazardous and intractable waste. The solution put forward involves the long-term storage (retrievable) or pemanent isolation of such wastes in an arid near surface clay geological repository that safeguards human health and the environment from harm over geological time. This can be achieved by applying proven scientific and environmentally sound management principles.

What are Class IV and Class V wastes?

The guidance document *Landfill Waste Classification and Waste Definitions* (DEC, 1996 as amended 2009) provides the WA definitions of Class IV and Class V landfills and the wastes they accept (Table 1-1).

Importantly, the definitions of hazardous and intractable wastes have the following meanings when mentioned in this PER:

- Hazardous – component of the waste stream which by its characteristics poses a threat or risk to public health, safety or the environment (includes substances which are toxic, infectious, mutagenic, carcinogenic, teratogenic, explosive, flammable, corrosive, oxidising and radioactive).
- Intractable – waste which is a management problem by virtue of its toxicity or chemical or physical characteristics, which make it difficult to dispose of or treat safely, and which is not suitable for disposal in Class I, II, III and IV landfill facilities.

The need for a Class V waste repository in Western Australia

WA is currently served by a network of landfills located throughout the state. The majority of these facilities are unlined Class I and II landfills accepting either Inert Waste (Class I) or putrescible waste (Class II). Class III landfills accept inert and putrescible waste also, but are lined and may have a leachate collection system.

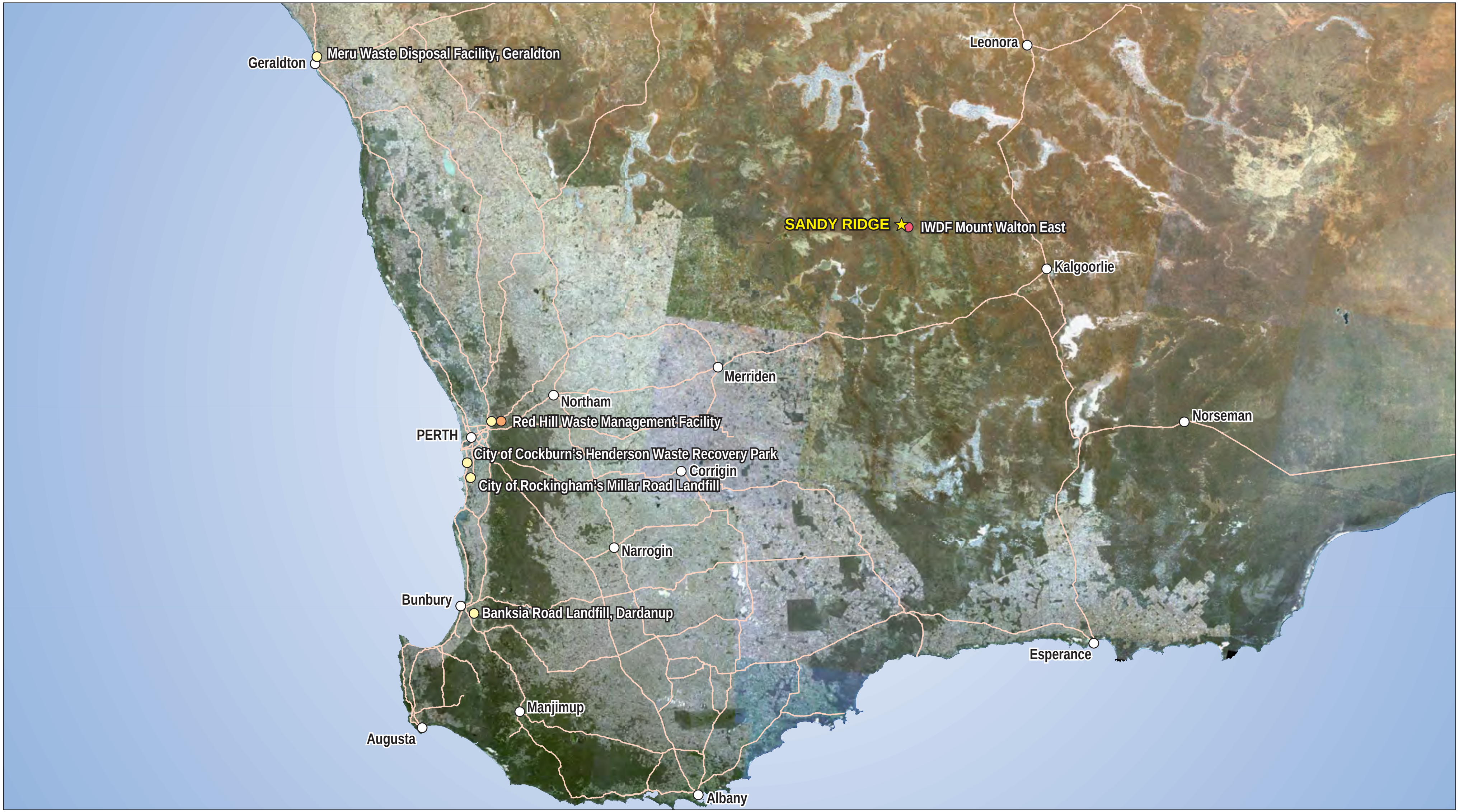
WA's only Class IV secure landfill accepting hazardous waste (Red Hill Waste Management Facility) is located within the Metropolitan area and opens intermittently (thelast opening was eight years ago). The Class IV landfill is double lined and has a leachate collection system. There is only one Class V Facility in WA and Australia (refer to Figure 2-1). No other states or territories in Australia have intractable waste disposal facilities.

The IWDF operates on a campaign basis in response to urgent market need and this, together with a very stringent regulatory regime and high disposal costs, means that the site has not hosted a disposal operation since 2008.

In addition, the state is served by a limited number of liquid waste treatment facilities primarily established to handle biological wastes such as septic, grease trap waste or oily water wastes.

Total Waste Management Services operates liquid waste treatment plants that accept a range of industrial liquid wastes at sites located in Perth and Kalgoorlie using neutralisation, gravity separation chemical fixation or immobilisation treatment methods.

Whilst there are a range of facilities, the hazardous and intractable waste end of the market is relatively poorly served in WA and as a result there is anecdotal evidence of stockpiling and incorrect management of hazardous and intractable waste.



Legend:
- Class III Landfill
- Class IV Landfill
- Class V Landfill
- Town Location
- Major Road

TELLUS

N

0 100km

Scale 1:5,000,000
MGA94 (Zone 51)

CAD Ref: g2294_PER_02_01.dgn

Date: Nov 2016 | Rev: C | A4

Author: C. Dorrington | AE Ref: THO2014-003

Drawn: CAD Resources ~ www.cadresources.com.au
Tel: (08) 9246 3242 ~ Fax: (08) 9246 3202

Sandy Ridge Facility
Western Australia's class IV and V landfills
Public Environmental Review

Figure: **2-1**

Reducing the viability of the site for future disposal of Class V wastes through the disposal of Class IV waste

The Sandy Ridge Proposal (for both Class IV and Class V wastes) would not reduce the viability of the site for future disposal of Class V wastes for several reasons:

- The Proposal does not rely on there being economically saleable kaolin resources to be able to permanently isolate waste materials in a geological repository. The vast majority of the Proposal site is suitable for waste storage by virtue of the site's geographical and geological features. Almost anywhere on the site which has sufficient depth of kaolinised granite, no water table, and the same surficial geology (silcrete, laterite gravel and clayey sands) and no heritage or special environmental constraints is likely to be suitable for waste cells.
- The annual waste acceptance (proposed licence limit) is 100,000 tonnes per annum for 25 years (i.e., 2.5 million tonnes total). The current proposed disturbance area (which is significantly less than the entire lease area proposed) is capable of storage of approximately 5.75 million tonnes of waste materials. Additional proposed Proposal lease area, which has not yet been applied for as disturbed area, is capable of storing an additional 7.75 million tonnes. This gives a total capacity (at maximum licenced annual waste acceptance rate) of some 135 years.
- There are no reasons why further lands outside the current proposed lease area could not be applied for in the future. Drilling by the IWDF in the 1990's and regional mapping by The proponent indicates that there is likely to be suitable areas of kaolinised granite over most of the region to the north, east and south-east of the proposed site which could be applied for if the Proposal was ever becoming constrained by lack of physical space and capacity.
- Class V wastes are by virtue of being at the bottom of the waste hierarchy always of a much smaller volume than Class IV wastes. Give the extremely long potential life of the Proposal (135 years or more), there is ample time in the future to re-address any limitations that might need to be placed on volumes of Class IV waste if space is becoming an issue.

National landfills

Each state or territory has different classifications for waste and landfills, which are summarised in Table 2-4. No other states or territories have intractable waste disposal facilities.

Table 2-4 Classification of waste and landfills in other jurisdictions of Australia

Jurisdiction	Waste classifications[7]	Landfill classifications	Approximate number of landfills (all classes)
New South Wales	Five classifications: • General (non-putrescible). • General (putrescible). • Restricted[8]. • Hazardous. • Special.	Three major categories of landfill, with sub-classes in two categories: • General solid waste (non-putrescible). • General solid waste (putrescible). • Hazardous – for any waste designated as hazardous.	85
Victoria	Five classifications: • Fill • Solid inert. • Putrescible. • Prescribed. • Prescribed (Contaminated Soil).	Three classifications based on acceptable waste types: • Type 1 – prescribed industrial waste containment Facility. • Type 2 – putrescible, inert, fill, and Category C Prescribed Industrial waste. • Type 3 – inert, fill.	57
Queensland	Two classifications: • General. • Regulated.[9]	Three categories: • Putrescible waste. • Non-putrescible waste. • Inert waste.	97
South Australia	Four classifications: • Inert. • Commercial and industrial (C&I) (General) – excludes listed wastes. • Construction and Demolition (C&D) (Inert) – excludes foreign materials[10]. • Municipal Solid Waste.	Landfill sites are classified according to the amount of waste received per annum, and the potential to generate leachate. The classes ranging from <1,000 tpa to >200,000 tpa.	71
Tasmania	Four classifications: • Solid inert.	Level 2 landfills receive >100 tpa and require management systems.	11

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[7] *'Wastes' refers to solid wastes other than clinical and related wastes.*
[8] *Restricted solid wastes in NSW are specifically gazetted – none have been nominated as yet.*
[9] *'Regulated Waste' in Queensland covers oils, tyres, clinical waste, asbestos, batteries, abattoir effluent and lead.*

[10] *'Foreign materials' – in the South Australia context includes green waste, plastics, electrical wiring, timber, paper, insulation, tins, packaging and other waste associated with construction or demolition of a building or other infrastructure. Foreign material must not be Municipal Solid Waste, Liquid, Listed, Hazardous or Radioactive Waste.*

Jurisdiction	Waste classifications[7]	Landfill classifications	Approximate number of landfills (all classes)
	• Potentially contaminated. • Putrescible. • Controlled.	as set out in legislation. There are three categories of landfill: • Category A – solid inert. • Category B – putrescible. • Category C – secure.	
Northern Territory	Four classifications: • Domestic garbage. • Hazardous. • Putrescible. • Clinical.	General A, B, C based on size. Classifications under development.	16

Source: Wrights Corporate Strategy Pty Ltd (2010) and Sustainable Resource Use (2012)

Why not utilise the IWDF?

Currently intractable waste generated in WA is disposed of at the state-owned and operated IWDF. Originally approved by the Minister for the Environment in 1992, the operation and acceptance of wastes at the IWDF has occurred in eight separate disposal events with the last occurring in 2008. It is recognised that the environmental setting, regional geology and hydrogeology of the area around the IWDF make the area world class in terms of a safety case for establishing an arid near surface geological repository for intractable waste.

It has been a recurrent issue for the WA Government to find a suitable government agency to take responsibility for operation of the IWDF. The IWDF was originally established under the control of the Department of Health but then transferred to the then Department of Environmental Protection when responsibility for waste regulation transferred to that agency.

This move made it necessary for the EPA to take up the role of regulator to resolve the conflict of interest created if the agency responsible for day-to-day regulation of the IWDF was also the operator. Subsequently a special purpose agency (known as Waste Management WA) was established in legislation to operate the IWDF and the Forrestdale Liquid Waste site. More recently, responsibility for the IWDF has been transferred three more times to the Department of Housing and Works, the Department of Treasury and Finance, and the Department of Finance.

The regular transfer of responsibility has resulted in a loss of corporate knowledge regarding the site within government, although the core experience and knowledge has been retained because the site is largely run by a Facilities Management Contractor and, the same contract personnel have been involved in operating the site since 1992.

The restrictive and complex regulatory framework for the IWDF means that it is operated as a site of last resort for receiving waste and the onus is on the waste holder to demonstrate that they have exhausted all other potential options for handling the waste materials before they can be directed to the IWDF. This, coupled with the very high cost structures associated with each disposal campaign and the infrequent basis on which it operates, means that the IWDF is a very unattractive disposal option for most waste holders who want a commercially run, cost competitive easy to use Facility. This is particularly so for those with smaller quantities of waste where the waste holder wishes to achieve disposal in a reasonable timeframe. Most waste producers also do not want to send their waste overseas to geological repositories in Europe and North America, if there is a viable local solution.

The result of the constrained nature of the IWDF is that there is little knowledge of its existence amongst the holders and generators of intractable waste. This situation has been further exacerbated by the fact the only Class IV landfill (Red Hill Waste Management Facility) has not been operational on a regular basis for a number of years. The constrained nature of the IWDF means that intractable wastes are being stored across the State (and country) on an ad hoc basis potentially with limited controls, representing a greater risk to the humans and the environment.

The proposed Facility would accept similar wastes to those accepted by the IWDF (i.e. contaminated soils from the mining industry and a small volume of LLW, like smoke desctors and sealed guages). The Proposal would provide waste producers with a commercially attractive option for storage, recovery or permanent isolation of their intractable wastes. This would provide a better quality service that would result in less waste being sent overseas, or stored temporarily, often in sub-optimal location. In addition, this would also relieve the WA Government and taxpayers from paying costs to operate the IWDF. The approval and commissioning of the Facility would also reduce the environmental risks associated with the long-term storage of intractable wastes while waiting for a disposal operation to occur at the IWDF.

The nature of the proposed Facility is quite different from the existing IWDF site as it would initially be open four days a week, 52 weeks a year to receive waste. By comparison, the IWDF site only operates on a campaign basis and has not accepted waste since 2008.

Volume trends in hazardous waste

The *Hazardous Waste Infrastructure Needs and Capacity Assessment* (Blue Environment Pty Ltd, 2015) projected waste volume growth for 29 waste groups individually over 20 years. Projections from the waste groups varied from a shrinkage (–3% per annum) to exponential growth (10% per annum), with the majority growing at an overall average volume growth of (3% per annum). Related market intelligence reports carried out by IBIS World (as cited in Ascend, 2015) estimate the following:

- Waste treatment and storage service in Australia is expected to grow 3.7% from 2016 to 2021.
- Waste remediation and materials recovery service is expected to grow 4.1% from 2016 to 2021.
- Hazardous waste hauling in Australia is expected to grow 4.0% from 2015 to 2020.

Figure 2-2 presents projected waste volumes in the hazardous waste market between 2014 and 2034. The figure shows that in 2016, Australia is expecting to produce approximately six million tonnes of hazardous waste. By 2034 that volume is anticipated to rise to 10 million tonnes. Of the total volume produced per annum in Australia, the proponent proposes to manage a very small portion (refer to the blue line) of the total volume shown in Figure 2-2.

The orange line in Figure 2-2 shows that despite a predicted increase of hazardous waste over the next 20 years, the proposed Facility is designed and seeking approval for, up to 100,000 tonnes (capacity) of hazardous waste per annum. Approval of the Facility, would not increase production of hazardous waste in Australia but, would increase the potential for the recovery of valuable materials at the proposed Future 'Technology Park on site, that could be pushed back into the circular economy.

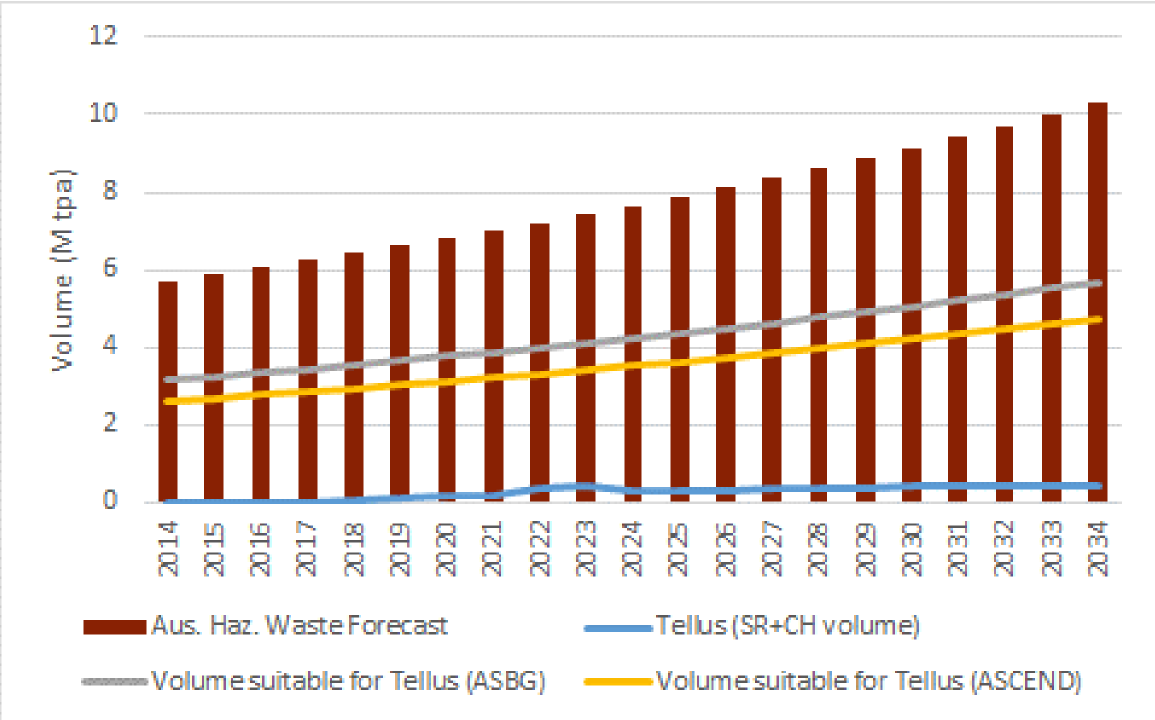


Figure 2-2 Total hazardous waste market and the proposed waste acceptance capacity

2.4.3 Market analysis of Australia's hazardous waste

Legacy waste

Legacy waste means those hazardous wastes that exist from previous historical activities. Table 2-5 presents legacy waste volumes in Australia for a range of waste types including spent pot liner (SPL), fly ash, red mud and other hazardous wastes from major mining, oil and gas, chemical production or heavy industry sites.

Table 2-5 Estimated legacy waste volumes in Australia

Legacy waste categories in Australia	Annual production (Mt)	Historical stockpile (Mt)	Source/comment
SPL (stockpiled)	0	0.8	'Annual generation' of 115,000 t included in ASCEND (2015) market estimates. Blue Environment Pty Ltd (2015) quotes current Australian stockpiles of 900,000 t. 'Historical stockpile quantity' calculated as Total Stockpile minus 'Annual generation'.
Fly ash (stockpiled)	6.6	400	Figures quoted from: Ash Development Association of Australia (2014).
Reported hazardous waste (2012-13)	5.5	0	ASCEND.
TOTAL	**38**	**900**	Rounded to two significant figures.

**Source: ASCEND (2015)*
Mt – million tonnes

Total forecast hazardous waste market is estimated to be approximately 6.4 million tonnes by 2018. If one assumes that as little as 0.5 to1.0% of the 900 million tonnes legacy waste begins to move off site from temporary locations, then this would add another 4.5 million tonnes per annum ontop of the 6.4 million tonnes from normal production profile by (Figure 2-3).

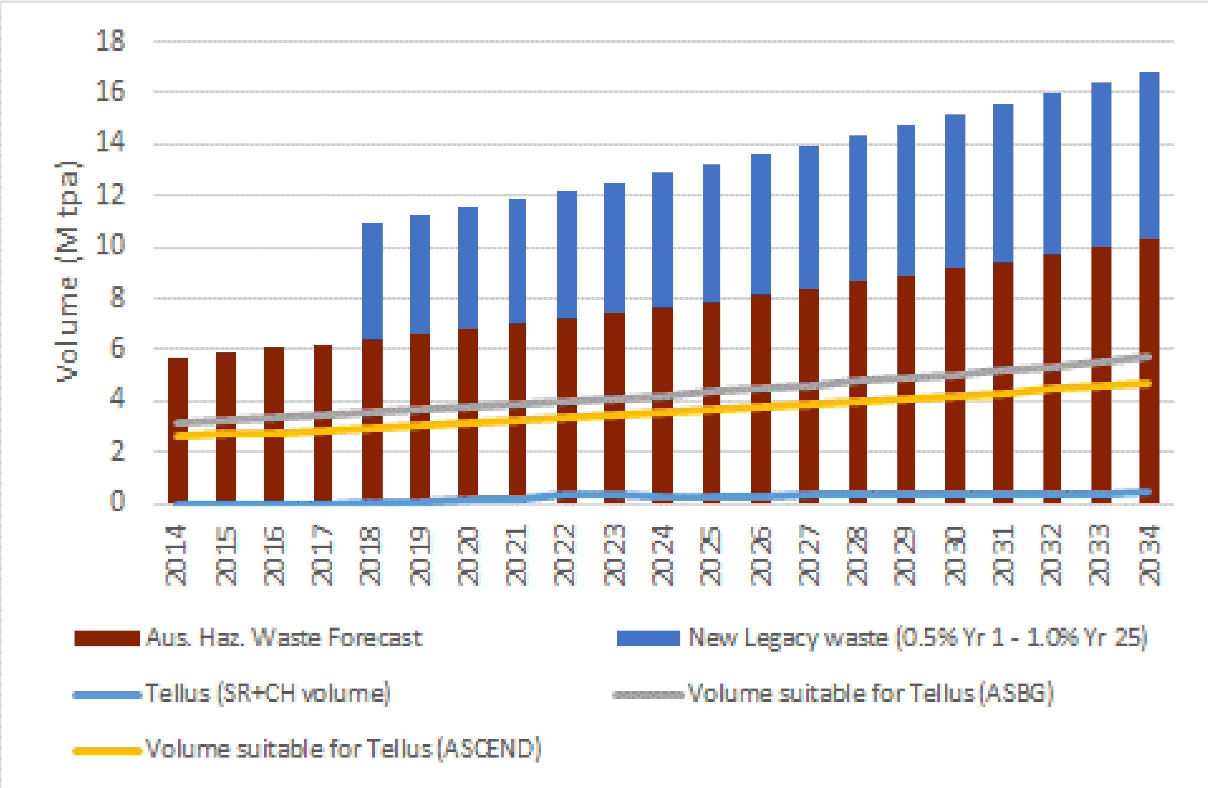


Figure 2-3 Total hazardous legacy waste market

Wastes relevant to the proposed Facility were chosen based on:

- The proponent's strict waste acceptance criteria that meets worlds best practice
- Wastes best suited for a near surface arid geological repository.
- The size of the Australian hazardous waste market by individual waste type.
- Potential regulatory or market barriers to entry for any of these wastes.
- The opportunity offered (per waste) through the combination of:
    - Potential volume.
    - Potential competitive price advantage.
    - Transport costs.
    - Perceived 'space' in the marketplace for the alternative storage option and isolation options.

Existing waste volumes

Australia produces approximately 5.5 to 6 million tonnes per annum of reported hazardous waste (KMH Environmental, 2013). WA produces approximately 0.9 million tonnes per annum of reported hazardous waste. Approximately 900 million tonnes of legacy waste, including hazardous and intractable waste generated historically, is estimated to be temporarily stored in over many locations across Australia, awaiting an appropriate long-term storage, recovery or permanent isolation. A market overview is provided in Table 2-6.

Category	Market overview
Market size – volume (Mt)	• Approximately 53.3 Mt. • Approximately 11% (5.9 M tpa) hazardous waste.
Growth (%)	Approximately 3.0–4.0% per annum.
Comparison	Australia is one of the highest emitters of hazardous waste on a per capita basis.
Legacy	Significant volumes currently stored around Australia in temporary facilities – significant liability exposures.

Table 2-6 Australian hazardous waste market summary

Controlled waste transported domestically between states and territories amounted to 188,000 tonnes during 2009–10, declining to 179,000 tonnes for 2010–11. These wastes consist primarily of inorganic chemicals, oils, soil/sludge, acids, alkalis, and putrescible/organics (Australian Bureau of Statistics [ABS], 2013). Approximately 10,529 tonnes were exported domestically from WA, and 40 tonnes imported from other states and territories during 2010-11 (ABS, 2013).[11].

[11] *It should be noted that discrepancies exist in the movements of controlled waste between states and territories due to consignment non-arrival, transport without authorisation, non-matching documentation and waste data.*

Market research of the waste industry sector in Australia identified eight waste generating sectors:

- Chemical trading companies.
- Waste companies.
- Mining companies.
- Hydrocarbons (e.g. oil and gas industry).
- Environmental engineering companies.
- Federal government (in terms of obtaining waste that is usually exported overseas and assisting with disposal of wastes during disaster events (e.g. oil spill).
- Other wastes.

These sectors would be the sources of wastes likely to be disposed of at the proposed Facility (refer to Figure 2-4).

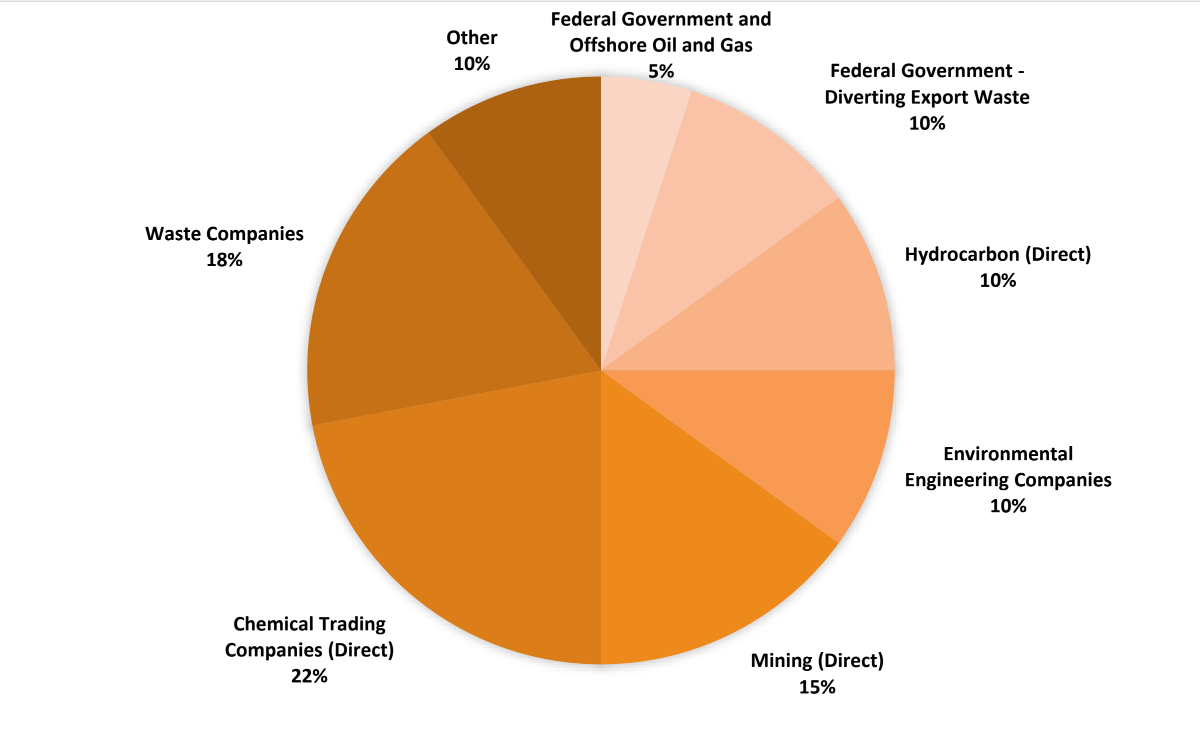


Figure 2-4 Waste sources by sector

For planning purposes, the proponent is assuming the Proposal would start below 50,000 tonnes per annum, average 66,00 tonnes per annum but would have a licenced capacity of 100,000 tonnes per annum of Class IV and V Hazardous and Intractable wastes to accommodate for both a steady state growth over 25 years and a surge as a result of a one-off campaign style State Emergency Service infrastructure requirements. For example, man-made or natural disasters where significant volumes of materials need to be rapidly removed from communities, or one off campaign style transfer of significant mine dumps or tailing ponds from a large industrial customer. The current market analysis suggests the volumes and sources of waste would be:

- 13,750 tpa from chemical trading companies which represent 22% of the market.
- 11,250 tpa from waste companies which represent 18% of the market.
- 9,375 tpa from mining companies which represent 15% of the market.
- A combined total of approximately 18,750 tpa, representing 35% of the market, would be sourced across environmental engineering companies, hydrocarbon (oil and gas) industry.
- The remaining 'other' volume of waste (9,400 tpa), representing 10% of the market, would be sourced from state or local governments (asbestos), heavy industry and construction companies.

Over the 25 year life of the proposed Sandy Ridge Facility, the volume of waste requiring long-term storage, recovery and isolation would vary due to:

- Advances in resource recovery technology.
- Industry and consumer behaviour in waste management.
- Fluctuation in market conditions and subsequent increase or decrease in major projects, resulting in a subsequent decrease or increase of waste generated.
- Frequency of state and national emergency events (e.g. man-made disasters like oil spills, road, rail, shipping accident or natural disasters like fire, flood and earthquake that requires clean up of communities, business and the environment after the event).
- Population growth, with Infrastructure Australia (2015) suggesting the population of Australia would be 30.5 million people in 2031, a growth of 8.2 million or 36.5% from 2011. The demand for residential and urban areas for the growing population may result in owners of historically stored wastes looking for alternative storage sites (e.g. Sandy Ridge).

2.5 Proposal benefits

The implementation of the Proposal would result in the following positive environmental, social and economic benefits to WA and Australia:

- Unique dual revenue business that commercialises an industrial bulk commodity kaolin and provides safe management solutions for difficult to manage hazardous waste resources as shown in Figure 2-5 and Figure 2-6
- The 'recover' versus 'protect' dilemma – the proponent can do both (see Figure 2-7).
- Future potential recovery of valuable materials.
- Long-term jobs, major investment and business opportunities in remote regional Australia.
- Diversification of the economy by an environmental infrastructure business with strong social, environmental and economic values.

- Royalties, taxes and levies over the 25 year term could support other parts of the economy.
- Employment and business opportunities that can support local and regional communities.
- Long Proposal life of 25 (plus) years. The site can be expanded for generations (one year build, two year operation).
- Jobs during the build phase: approximately 90 and during the operation phase: approximately 23 direct and 46 indirect (2x multiplier).
- Benefits would apply to local Indigenous communities where opportunities for training, employment and business opportunities during construction and operations exist.
- Building of enabling infrastructure that provides cost competitive worlds best practice waste solutions to the mining, oil & gas, manufacturing industries and government for some of their most difficult to manage wastes that would otherwise meet their national and international obligations.
- Addition of infrastructure that can provide long term storage, or permanent isolation services that minimise adverse impacts of the hazardous waste on the environment and human health.
- Development of infrastructure that could support the recovery of valuable materials back into the circular economy.
- The Facility could attract new kaolin and waste recycle and recovery industries to WA bringing attendant economic benefits.
- Government also has Environmental and Hazardous Waste Policies that this Proposal would help met (subject to meeting the proponent's WAC) for example:
    - Environmental Protection Regulations - minimising adverse impacts on environment and human health and meeting national and international obligations
    - Sustainability and Product Stewardship Regulations -for example waste oil, asbestos, e-waste, tyres, batteries, mercury, medicines etc
- Occupational Health and Safety (OHS) Regulations - Reduce OHS risk in the workplace

The proposed development reflects the objectives of the Government's approach to developing the Goldfields area not only as a mining area but also to diversify the economy by supporting innovative environmental utility businesses that can bring significant investment, increase trade, provide long-term jobs in regional Australia and provide enabling infrastructure services to the mining, oil and gas, manufacturing and agricultural industry.

The establishment of the Proposal would allow the State to defer the IWDF, which would save approximately $7.5 million (in today's money) over the 25 year life of the mine.

Best practice environmental waste management handling in Western Australia

The lack of disposal operations at the IWDF means that potentially hazardous and intractable wastes are being stockpiled potentially in undesirable circumstances around WA. Current management of hazardous and intractable waste at unknown locations across WA, may pose a significant environmental risk due to their locations near sensitive environmental receptors.

The potential role of Sandy Ridge within the circular economy

The proponent believes that waste is a valuable resource and we should find ways for it to be recovered and re-enter the circular economy or stored safely until it can be reused or recycled.

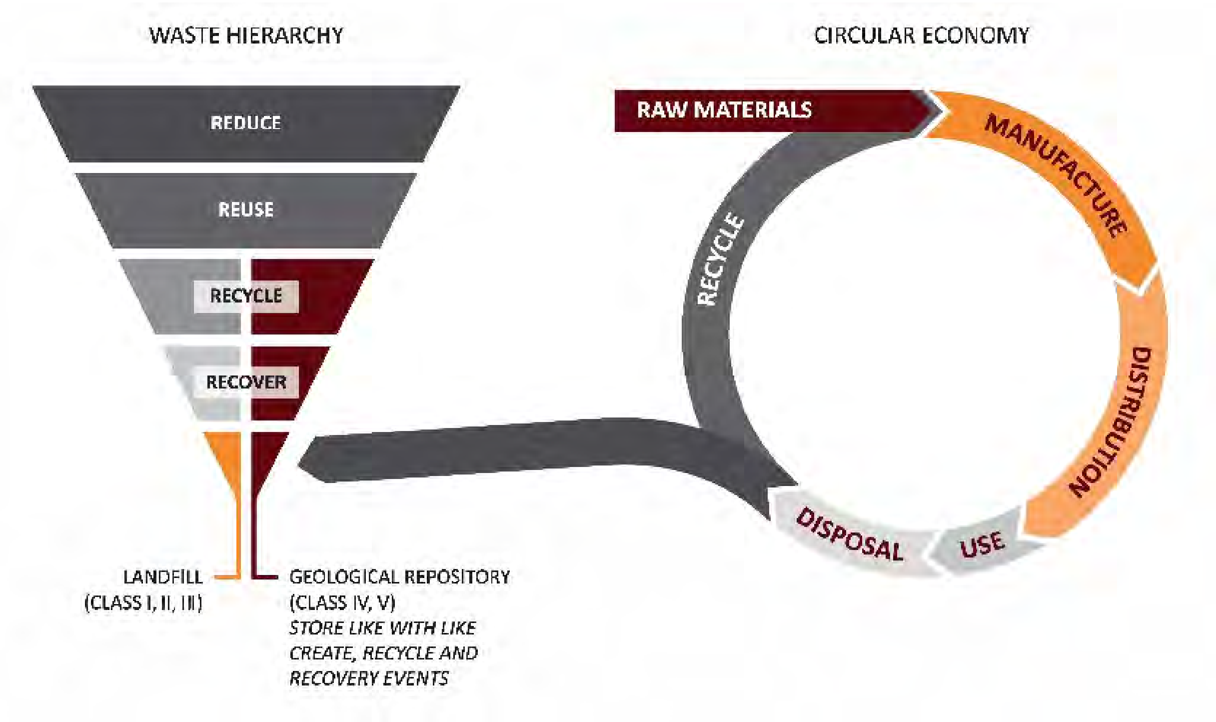


Figure 2-5 Proposal benefits associated with environmentally sound management

The opportunities presented due to economies of scale, storing "like with like" and looking at the materials on a molecular level is what the proponent believes is the key to converting the waste into a valuable resource and positioning Australia as a leader in high-value niche products.

We can achieve this only if researchers, industries, waste generators and the waste industry work together with a technology recovery toolbox that can recover new green materials, new intellectual property and associated science and technology-based products and services.

The proponent plans to host these technologies at our own research and development (R&D) future technology parks, located at the proposed Sandy Ridge Facility.

The main benefits of the proponent's resource recovery and recycling solutions are:

- The proponent specialises in difficult to manage hazardous materials

- Customers sharing the same values as us where we both see waste as a valuable resource where we should find ways for it to re-enter the circular economy or stored safely until it can be reused or recycled
- Domestic solution supporting new value-added green materials and resources, instead of shipping our waste offshore
- Reducing environmental pressures in Australia and beyond
- Minimising Australia's high and increasing dependence on imports
- Increasing the competitiveness and social license to operate of Australia's industry
- The proponent will deliver opportunities to revolutionise the domestic recycling industry through the creation of new enterprise, associated technology and jobs
- A strong domestic recycling sector can deliver significant cost reductions to Australian industries

Supporting an innovative company in the business of finding economic, environmental and social value in some difficult to manage wastes.

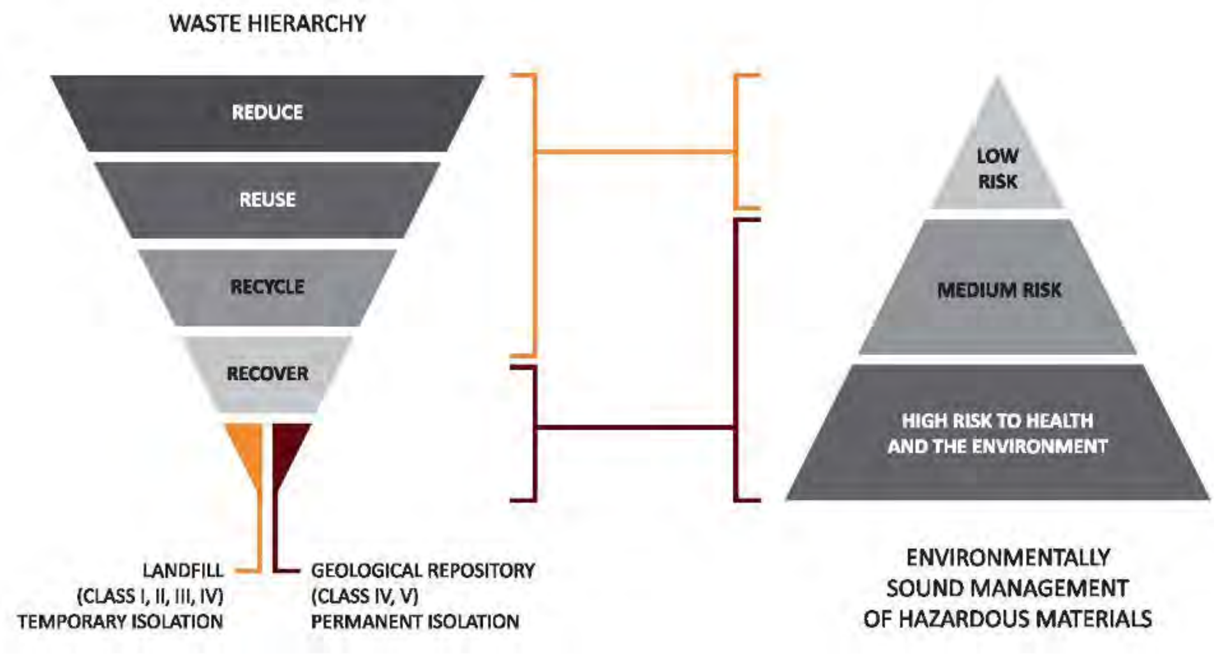


Figure 2-6 Proposal benefits with the management of Class IV and Class V hazardous wastes

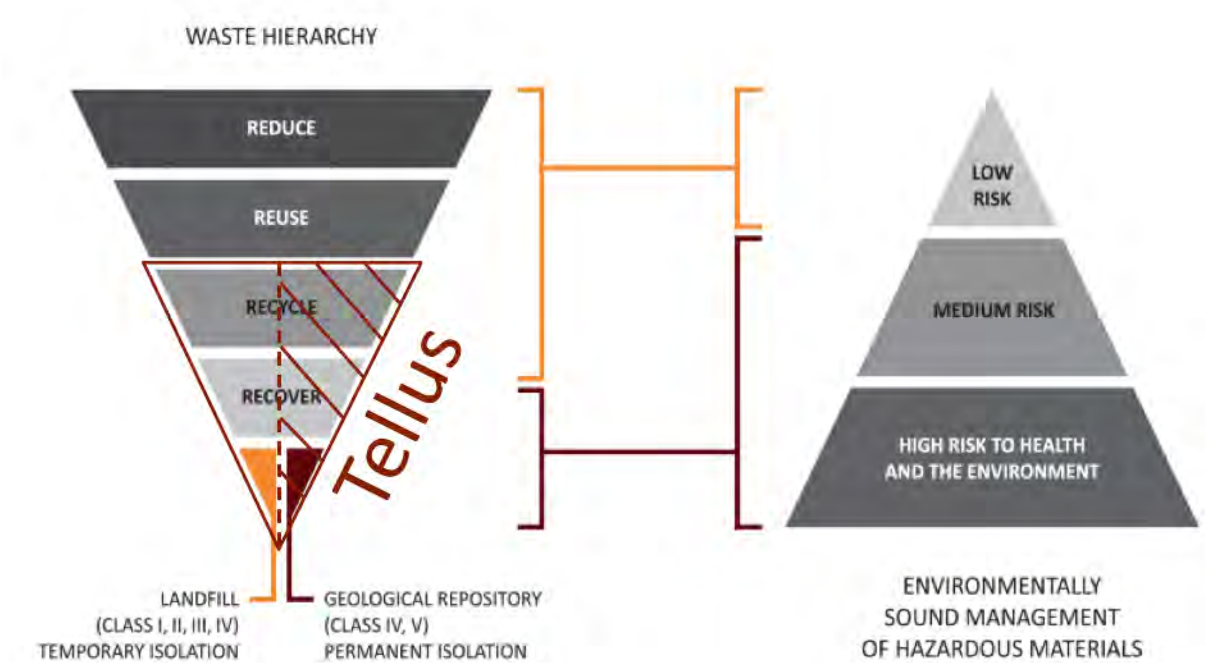


Figure 2-7 Proposal benefits with the management of Class IV and Class V hazardous wastes

3 ENVIRONMENTAL ASSESSMENT PROCESS

3.1 What is the purpose of the environmental assessment process?

The environmental assessment process serves an important procedural role in the overall decision-making process by promoting transparency and public involvement.

The environmental assessment process combines research from a wide variety of scientific disciplines and aspects e.g. water, ecology, climate, social etc. The combination of environmental criteria is used to improve design and management decisions. It assists in assessing whether Proposals may positively or negatively impact the environment through various stages of proposed activities, e.g. construction, operation and closure.

The objective of the environmental assessment process is to inform (regulatory) decision-makers and the public of potential environmental consequences of implementing a proposed development. If the environmental assessment process is successful, it identifies alternatives and mitigation measures to reduce the environmental impact of a Proposal (ELAW, 2010).

3.2 What are the benefits of the environmental assessment process?

The benefits of carrying out an environmental assessment include:

- Screening out environmentally inappropriate options within a development.
- Identifying feasible Proposal alternatives.
- Modifying design to enhance potentially beneficial Proposal impacts.
- Modifying designs to reduce potentially adverse environmental impacts.
- Predicting significant positive and/or adverse impacts through risk assessment.
- Identifying management measures to avoid, reduce, offset or eliminate major adverse impacts.
- Engaging and informing potentially affected communities and individuals.
- Assisting in decision making and the development of appropriate conditions of consent.

The environmental assessment process, while not uniform in Australia, generally consist of a series of procedural steps that culminate in a written impact assessment report that would inform regulators whether to approve or reject a proposed development. The environmental assessment process that is undertaken in WA by the Commonwealth Department of the Environment and Energy (DoEE), is explained below.

3.3 Western Australian process

The WA Environmental Impact Assessment process is triggered by a referral under Part IV (Section 38) of the *Environmental Protection Act 1986*. The EPA is a five-member statutory authority and is the primary provider of independent environmental advice to the Minister for Environment; Heritage.

The EPA implements the *Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures 2012* in conducting assessments of Proposals and its effects on the environment. A description of the proposed Sandy Ridge Facility environmental assessment process is provided below. A flow chart of the steps in the environmental assessment process is provided in Figure 3-1.

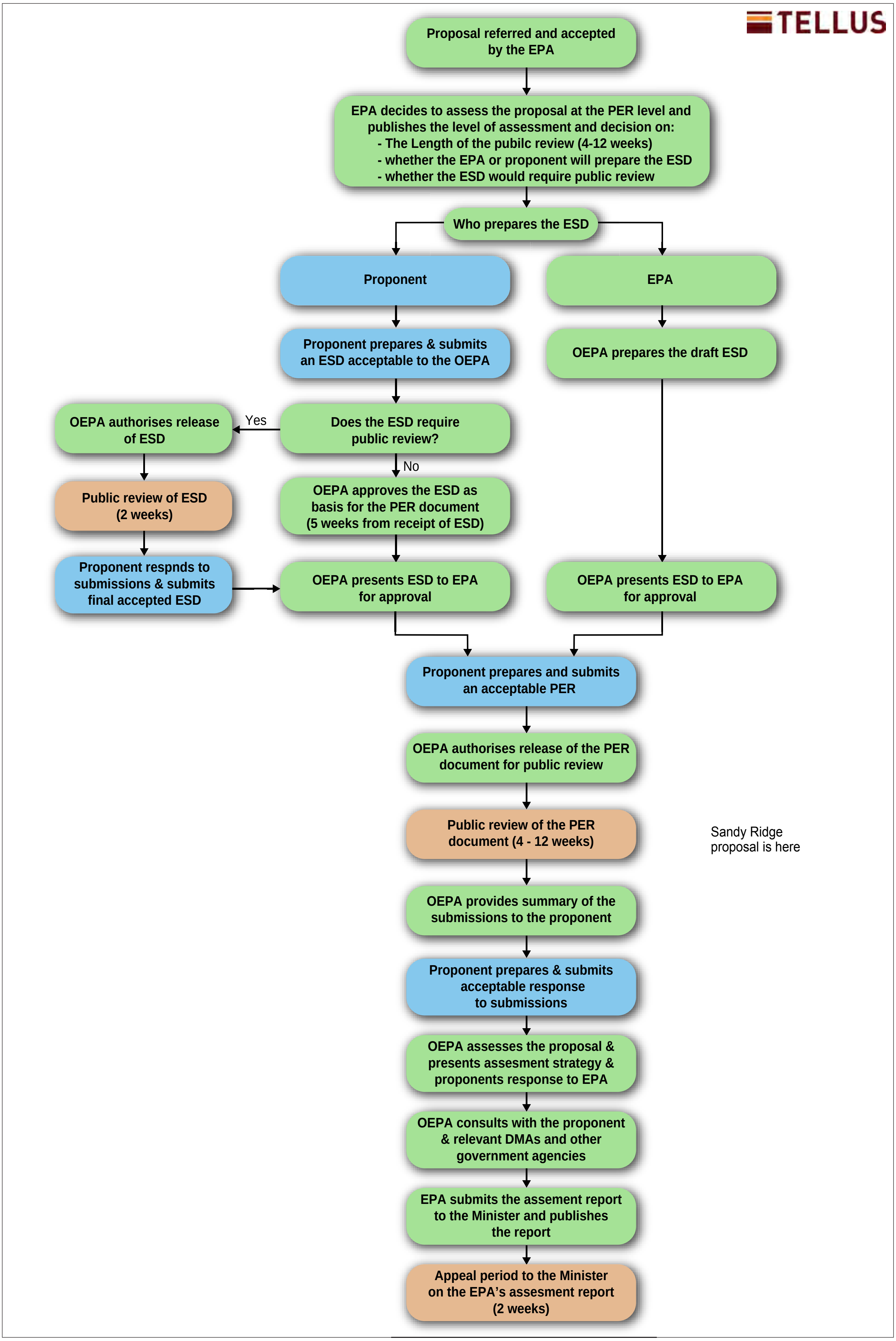
3.3.1 Referral

Section 38 of the EP Act makes provision for the referral to the EPA of a proposal (significant proposals, strategic proposals and proposals under an assessed scheme) by a proponent, a decision making authority (DMA), or any other person. The referral documentation consists of a form, and supporting documentation about the proposal, that gives the EPA enough information to make a decision on the Level of Assessment for the proposal.

Following discussions with a range of stakeholders, including the OEPA, the proponent submitted a referral of the Proposal on 4 May 2015 to the OEPA. The referral was advertised for public comment over seven days. After the close of the advertising period, and consultation with key government departments, the EPA determined the Proposal should be assessed at the level of PER. A PER is applied where:

- The Proposal is of regional and/or state-wide significance.
- The Proposal has several significant environmental issues or factors, some of which are considered to be complex or of a strategic nature.
- Substantial or detailed assessment of the Proposal is required to determine whether, and if so how, the environmental issues could be managed.
- The level of interest in the Proposal warrants a public review period.

The PER process is shown as a diagram in Figure 3-1.



CAD Ref: g2294_PER_03_01	Aurora environmental	**Sandy Ridge Facility**	Figure:	
Date: November 2016 | Rev: B | A4	Author: C. Dorrington | AE Ref: THO2014-003	Environmental Impact Assessment process	**3-1**	
	Drawn: CAD Resources ~ www.cadresources.com.au Tel: (08) 9246 3242 ~ Fax: (08) 9246 3202	**Public Environmental Review**		

3.3.2 Scoping

An ESD is the document prepared by either the EPA, or by the proponent in conjunction with the EPA (as was the case for this Proposal), which sets out the EPA's determination as to the form, content, timing and procedure of environmental review required to be undertaken by the proponent under Section 40(2)(b) of the EP Act where the PER level of assessment has been determined by the EPA. The purpose of the ESD is to:

- Develop proposal-specific guidelines to direct the proponent on the key environmental issues for the proposal that should be addressed in preparing the PER document.
- Identify the necessary impact predictions for the proposal, and the information on the environmental setting required to carry out the assessment.

The ESD was released for a two-week public comment period on 31 March 2016. The key environmental factors identified in the ESD include:

- Flora and vegetation.
- Terrestrial environmental quality.
- Terrestrial fauna.
- Inland waters environmental quality.
- Human health.
- Heritage.
- Offsets (integrating factor).
- Rehabilitation and decommissioning (integrating factor).

In addition, amenity (in relation to noise, dust and visual impacts) and viability of the water source was considered relevant to the Proposal.

The ESD was approved by the EPA board on 27 May, 2016 (refer to Appendix A.1).

3.3.3 Investigations and assessment of significance

In line with the requirements of the ESD, appropriate information was collated and various environmental studies were conducted within the proposed development envelope. The results of desktop research and 12 months of field investigations have been documented within this PER (refer to Chapters 9 and 10).

An environmental risk assessment was completed by the Proposal team to identify and analyse all risks presented by operational aspects of the Proposal. The outcomes of the risk assessment are provided in the report within Appendix A.2.

An assessment of significance for each key environmental factor identified by the EPA has been considered with respect to environmental risks and documented (Chapter 9). Appropriate management measures to achieve the predicted environmental outcome have also been documented.

3.3.4 Government assessment process

Following acceptance of this PER by OEPA, and once the EPA is satisfied that the PER has been prepared in accordance with the requirements of the approved ESD, the public is invited to make comment on the Proposal during a 10 week advertising period.

The EPA collates the submissions and the proponent responds by providing clarification or extra information to support the Proposal, or potentially amending the Proposal to address relevant issues that have been raised during the consultation process.

The EPA then continues its assessment and may seek comment from key DMAs within government on any draft recommended conditions to be imposed on the Implementation Statement if issued by the Minister for Environment; Heritage. The EPA submits its report to the Minister for Environment; Heritage and simultaneously publishes the EPA Report. Third parties have the right of appeal on the EPA's report. Any appeals must be considered and determined before a final decision can be made by the Minister to approve or reject the Proposal.

On completion of the appeals process, the WA Minister for Environment; Heritage makes the final determination on the Proposal, including the conditions to be implemented by the proponent. The decision by the Minister can be appealed but only by the proponent.

3.3.5 Environmental principles

This PER document acknowledges the core principles of environmental protection set out in the EPA guideline *Environmental Assessment Guideline for Environmental Principles, Factors and Objectives (EAG 8)* (2015a). These principles have been considered in the preparation of this PER.

Core principles are:

1. The Precautionary Principle

Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

In the application of the precautionary principle, decisions should be guided by:

- *(a) Careful evaluation to avoid, where practicable, serious or irreversible damages to the environment; and*
- *(b) An assessment of the risk-weighted consequences of various options.*

2) The Principle of Intergeneration Equity

The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.

3) *The Principle of the Conservation of Biological Diversity and Ecological Integrity*

Conservation of biological diversity and ecological integrity should be a fundamental consideration.

4) *Principles in relation to Improved Valuation, Pricing and Incentive Mechanisms*

- *(1) Environmental factors should be included in the valuation of assets and services.*
- *(2) The polluter pays principle – those who generate pollution and waste should bear the cost of containment, avoidance or abatement.*
- *(3) The users of goods and services should pay prices based on the full life cycles costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any wastes.*
- *(4) Environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structures, including market mechanisms, which enable those best placed to maximise benefits and/or minimise costs to develop their own solutions and responses to environmental problems.*

5) *The Principle of Waste Minimisation*

All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.

6) *Best Practice*

When designing proposals, and implementing environmental mitigation and management actions, the contemporary best practice measures available at the time of implementation should be applied.

7) *Continuous Improvement*

The implementation of environmental practices should aim for continuous improvement in environmental performance.

3.4 Australian Government process

The Australian Government's environmental assessment process for significant impacts on matters of national environmental significance (MNES) is triggered by referral from the proponent under Section 68 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The proposed Sandy Ridge Facility was referred to the Commonwealth DoEE on 18 May 2015. The Federal Minister for the Environment determined the proposed action was a 'Controlled Action' and required assessment and approval under the EPBC Act. The proposed action was determined to be a 'Controlled Action' due to it being considered a nuclear action.

The action would be assessed under the Bilateral Agreement[12] with WA (Agreement between the Commonwealth of Australia and WA under Section 45 of the EPBC Act relating to environmental assessment).

For information on Commonwealth and WA legislation applicable to the Proposal refer to Chapter 4.

[12] *Bilateral agreements reduce duplication of environmental assessment and approval processes between the Commonwealth and states/territories. They allow the Commonwealth to 'accredit' particular state/territory assessment and approval processes.*

4 LEGISLATIVE FRAMEWORK

4.1 Introduction

This chapter provides an overview of the environmental approvals require for the Proposal. A list of the relevant environmental legislation, regulations, conventions, treaties, policies, guidelines and code of practices that are relevant to the implementation of the Prposal are provided.

The key environmental approvals for the Proposal includes Part IV approval under the EP Act and approval under the EPBC Act. Sections of the EP Act that are relevant to the Proposal are detailed in Table 4-1.

The PER must address the requirements set out in the ESD, Section 10.2.4 of the EPA's *Environmental Impact Assessment (Part IV Divisions 1 and 2), Administrative Procedures 2012* and Schedule 4 to the EPBC Regulations).

4.2 Environmental Protection Act 1986

The EP Act and its subsidiary legislation provides for the prevention, control and abatement of pollution and environmental harm, for the conservation, preservation, protection, enhancement and management of the environment. The EPA is tasked with assessment of proposals to ensure environmental protection and to prevent, control and abate pollution and environmental harm.

4.3 Environment Protection Biodiversity Conservation Act 1999

The EPBC Act is administered by the Commonwealth DoEE. As described in Section 3.4, the Commonwealth Minister for the Environment has agreed that the Proposal can be assessed under the terms of the Bilateral Agreement between the Commonwealth Government and WA. As a result, a single environmental assessment process would be completed under Part IV of the EP Act.

The EPBC Act regulates activities to protect and manage MNES. The EPBC Act has several objectives:

- Provide for the protection of the environment, especially MNES.
- Conserve Australian biodiversity.
- Provide a streamlined national environmental assessment and approvals process.
- Enhance the protection and management of important natural and cultural places.
- Control the international movement of plants and animals (wildlife), wildlife specimens and products made or derived from wildlife.
- Promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources.
- Recognise the role of Indigenous people in the conservation and ecologically sustainable use of Australia's biodiversity.

- Promote the use of Indigenous peoples' knowledge of biodiversity with the involvement of, and in cooperation with, the owners of the knowledge.

Approval from the Australian Minister for the Environment (or delegate) is being sought under Section 133 of the EPBC Act. This process is described in detail in Section 3.4. Subject to approval of the Proposal under Part IV of the EP Act, other construction and operation related approvals would also be sought.

Table 4-1 Key legislation relevant to the approval of the proposed Sandy Ridge Facility

Legislation	Approval	Decision Making Authority
EP Act (Section 45)	Statement that a Proposal may be implemented under Section 45.	Western Australian Minister for Environment; Heritage.
EPBC Act (Section 133)	Approval for the Proposal under Section 133.	Australian Minister for the Environment (or delegate).
***Mining Act 1978* (WA)**	• Mining lease under Section 71. • Grant of a general purpose lease in favour of Tellus under Section 86. • Miscellaneous licences under Section 91. • Mining Proposal and Mine Closure Plan under Section 82A (2).	Western Australian Minister Department of Mines and Petroleum.
Land Administration Act 1997	Land administration and land tenure.	The *Land Administration Act 1997* (WA) (LAA) governs the disposition and management of Crown land in WA. Among other things, the LAA outlines the processes relating to Crown leases and reserves, Crown easements and compulsory land acquisition. The waste storage or permanent isolation aspect of the Proposal would operate on land that is currently unallocated Crown land and accordingly, would require tenure that is granted pursuant to the LAA (namely a Crown lease or reserve and Crown easements). This would in turn require the compulsory acquisition of rights and interests in the affected areas to the extent necessary to enable the grant of the Crown lease and Crown easements. Primarily, and in combination with the requirements of the *Native Title Act 1993* (Cth) the compulsory acquisition of native title rights and interests would be required except to the extent that native title has already been extinguished in those areas. The approvals required under the LAA

Legislation	Approval	Decision Making Authority
		comprise an order that interests in land may be taken under Section 165 of the LAA, various steps, notices and orders under the compulsory acquisition processes in Parts 9 and 10 of the LAA to enable the taking of the relevant interests and the grant of the Crown lease and Crown easements.
EP Act (WA) – Part V	Works Approval (under Section 54) and Licence (under Section 57) for the construction and operation of kaolin processing plant.	Department of Environment Regulation.
EP Act (WA) – Part V	Works Approval (under Section 54) and Licence (under Section 57) for the construction and operation of waste repository (Class V/IV) and Class II landfill.	Department of Environment Regulation.
Native Title Act 1993	Aboriginal land interests because native title processes would need to be followed for the valid grant of tenure.	The *Native Title Act 1993* (Cth) regulates the recognition and protection of native title and, among other things, specifies the procedures to be complied with for certain future acts which may affect native title, including the valid grant of tenure. Unless native title rights and interests in the relevant area have already been extinguished, there would be processes to be followed by the DMP and the Department of Lands under the *Native Title Act 1993* (Cth) in order to validly grant tenure to the proponent.
***Radiation Safety Act 1975* (WA)**	Registration (under Section 28)/Disposal Permit (under Section 34).	Radiological Council of Western Australia.
Nuclear Non-Proliferation (Safeguards) Act 1987	Permit to possess nuclear material[13] under Section 13.	Australian Safeguards and Non-Proliferation Office within the Department of Foreign Affairs and Trade.
Mines Safety and Inspection Regulations 1995 (WA)	Radiation Management Plan under Part 16.	DMP.
***Rights in Water and Irrigation Act 1914* (WA)**	Licence to Take Water under Section 5C.	Department of Water

[13] *The Facility will not accept depleted uranium, enriched uranium, low enriched uranium, high enriched uranium, Uranium-233 or plutonium, but would accept natural uranium and thorium. See Glossary for further definition of these words.*

Legislation	Approval	Decision Making Authority
Dangerous Goods Safety Act 2004 **(WA) and** ***Dangerous Goods Safety (Storage and Handling of Non-explosives) Regulations 2007*** **(WA)**	Dangerous Goods Site Licence under Part 4.	DMP.
Planning and Development Act 2005 **(WA) and** ***Building Act 2011*** **(WA)**	Development approval under Section 162. Building permits for construction of buildings under Part 2.	Shire of Coolgardie.
Mines Safety and Inspection Regulations 1995 (WA)	Project management plan under Regulation 3.13.	DMP.

** Department of Mines and Petroleum*

4.4 Other legislation

Other Commonwealth and State legislation that may be applicable to the Proposal is listed in Table 4-2. The proponent has lodged applications for miscellaneous and general purpose licences as well as an outline Mining Plan. In addition, a licence to accept low level radioactive waste has also been progressed. Future licences and/or permits include vegetation clearance and water abstraction from the Carina mine pit. However, other agencies are constrained from approving the proposal until the Western Australian Minister for Environment has made his decision.

Table 4-2 Other relevant legislation

Legislation	Application	Decision Making Authority
Commonwealth legislation		
Australian Radiation Protection and Nuclear Safety Act 1998	Regulation (under Part 5) and inspection (under Part 7) of the Facility.	ARPANSA.
National Greenhouse and Energy Reporting Act 2007	Potential reporting requirements in relation to greenhouse gas emissions, energy production and energy consumption.	Clean Energy Regulator.
Nuclear Non-Proliferation (Safeguards) Act 1987	Report of inventory of nuclear material as required by the Permit.	Australian Safeguards and Non-proliferation Office within the Department of Foreign Affairs and Trade.
Western Australian legislation		
Aboriginal Heritage Act 1972	Protection of archaeological and ethnographic heritage sites.	Minister for Aboriginal Affairs.
Biosecurity and Agriculture Management Act 2007	The control of declared pests.	Department of Agriculture and Food.
Bush Fires Act 1954	Wild fire control.	Department of Fire and Emergency Services.
Contaminated Sites Act 2003 and the Contaminated Sites Regulations 2006 (WA)	Management of pollution.	Department of Environment Regulation.
Environmental Protection Act 1986 and regulations: • Environmental Protection (Controlled Waste) Regulations 1997 • Environmental Protection (Noise) Regulations 1997 • Environmental Protection (Rural Landfill) Regulations 2002	Management of controlled waste, noise, pollution control, maintenance and closure of Class II landfill.	Department of Environment Regulation
Food Act 2008	Public health as it relates to providing food.	Department of Health.
Health Act 1911	Public health as it relates to waste management.	Department of Health.

Legislation	Application	Decision Making Authority
Local Government Act 1995	Development approvals and management/community issues/resources/facilities.	Western Australian Local Government Association/Shire of Coolgardie.
Nuclear Activities Regulation Act 1978	Prohibits the storage, handling, disposal or transportation of any prescribed substance.	Radiological Council of Western Australia.
Nuclear Waste Storage and Transportation (Prohibition) Act 1999	Prohibits the storage, disposal or transportation of certain nuclear material.	Minister for Health.
Occupational Safety and Health Act 1984	Occupational health and safety.	Department of Commerce.
Radiation Safety Act 1975 and Radiation Safety (General) Regulations 1983, Radiation Safety (Qualifications) Regulations 1980	Radiation safety approvals. Prohibits the disposal of solid radioactive waste by near-surface disposal unless the disposal, the disposal Facility and the disposal site comply with the requirements of the appropriate code of practice.	Radiological Council of Western Australia.
Soil and Land Conservation Act 1945	Protection of soil resources.	Department of Agriculture and Food.
Wildlife Conservation Act 1950	Protection of threatened, rare or endangered species.	Department of Parks and Wildlife.

4.4.1 Proposal relationship to the *Nuclear Waste Storage and Transportation (Prohibition) Act 1999*

In 1999 Pangea Resources, a United Kingdom based company, identified Australia as a potential location for a deep geological repository to store high level waste and spent fuel from nuclear power production (WNA, 2015b). In response to Pangea Resources' proposal, WA introduced the *Nuclear Waste Storage and Transportation (Prohibition) Act 1999*. The objects of this Act are to protect the health, welfare and safety of the people of WA and to protect the environment in which they dwell by prohibiting the establishment of a nuclear waste storage Facility in the state, the use of any place in the state for the storage or disposal of nuclear waste, and the transportation in the state of nuclear waste.

The definition of nuclear waste in this Act is:

Nuclear waste means material –

a) that is or contains a radioactive substance; and

b) that –

a. is a waste of a nuclear plant;

b. results from the testing, use or decommissioning of nuclear weapons.

The definition excludes radioactive waste, such as that which might be generated by mining or the oil and gas industry, that is naturally occurring uranium and thorium.

The proponent's Proposal differs from Pangea Resources' in two key areas:

- The proponent is proposing to accept LLW, and has no intention of accepting nuclear waste or nuclear material at the Facility. Pangea Resources proposed to accept nuclear waste (high level waste and spent fuel).
- A near surface repository is proposed (within 30 m of the ground surface), whereas Pangea Resources was proposing a deep geological repository (500 m below the ground surface).

The WA legislation definition of nuclear waste differs from the definition provided in the EPBC Act and EPBC Regulations. Under Australian legislation, the Facility is deemed a 'nuclear action' because it proposes to accept radioactive waste with activity concentrations greater than prescribed levels. While not accepting nuclear waste, the label 'nuclear' is applied because it is proposed to accept NORMs, medical radioisotopes or commercial and domestic radioactive equipment that may meet or exceed the threshold concentrations and activities prescribed in Schedule 2 Part 2 of the Australian Radiation Protection and Nuclear Safety Regulations 1999 (Cth). This exceedance of threshold concentrations automatically triggers the 'nuclear action'; however, the material to be accepted is still within the definition of LLW. More information on the 'nuclear action' is provided in Section 11.2.

4.5 International conventions and treaties

4.5.1 London Protocol

The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972, or the 'London Convention', was one of the first global conventions to protect the marine environment from human activities (International Maritime Organisation [IMO], 2015). In 1996, the London Protocol was agreed by Parties to the Convention to further modernise the Convention and, eventually, replace it (IMO, 2015). Under the London Protocol all dumping of wastes is prohibited, except for possibly acceptable wastes on the so-called 'reverse list'. The reverse list includes dredged material, sewage sludge, fish wastes, vessels and platforms, inert inorganic geological material (e.g. mining wastes), bulky items primarily comprising iron, steel and concrete, and carbon dioxide streams from carbon dioxide capture processes for sequestration. The Protocol was adopted in 2006. There are currently 45 Parties to the Protocol, including Australia (IMO, 2015).

The convention is implemented in Australia under the EPBC Act and the *Environment Protection (Sea Dumping) Act 1981* and Environmental Protection (Sea Dumping) Regulations 1983. The Act applies to all vessels, aircraft and platforms in Australian waters and to all Australian vessels and aircrafts in any part of the sea. Australian waters mean:

a) *the territorial sea of Australia and any sea that is on the landward side of the territorial sea of Australia, other than any part of the sea that is within the limits of a State or of the Northern Territory; or*

b) *the territorial sea of an external Territory and any sea that is on the landward side of that territorial sea; or*

c) *the exclusive economic zone adjacent to the coast of Australia or the coast of an external Territory; or*

d) *any other area of sea that is above the continental shelf of Australia or above the continental shelf of an external Territory.*

and includes any area of sea that is declared by the regulations to be included in Australian waters for the purposes of the Act.

Wastes generated in Australian waters, for example NORMs are prohibited from being disposed of in Australian waters. The Proposal would provide a long-term storage solution for these wastes and aids Australia in complying with the spirit of the London Protocol.

4.5.2 Nuclear Non-Proliferation Treaty and Convention on the physical protection of nuclear material

The Treaty on the Non-Proliferation of Nuclear Weapons (Non-Proliferation Treaty) (NPT) and the non-proliferation safeguards system provided through the IAEA assist in limiting the spread of nuclear weapons and contributing to international peace and security (Department of Foreign Affairs and Trade, 2015).

The Convention on the Physical Protection of Nuclear Material (CPPNM) is the only international legally binding undertaking in the area of physical protection of nuclear material. The convention establishes measures related to the prevention, detection and punishment of offenses relating to nuclear material (IAEA, 2015). The Convention was signed at Vienna and at New York on 3 March 1980.

The Australian Safeguards and Non-proliferation Office (ASNO) ensures that Australia's international obligations are met under the NPT, the safeguards agreement with the IAEA, the CPPNM and Australia's various bilateral safeguards agreements (of which there are currently 20).

The ASNO's requirements would be adhered to, ensuring the Propsal's waste acceptance does not breach any obligations for which ASNO is responsible for.

4.5.3 JAMBA, CAMBA and ROKAMBA and Bonn Convention

Australia is party to the Japan–Australia (JAMBA), Republic of Korea–Australia (ROKAMBA), China–Australia (CAMBA) and the Bonn Convention (Convention of the Conservation of Migratory Species of Wild Animals) 1979 Migratory Bird Agreements. All migratory bird species listed in the annexes to these bilateral agreements are protected in Australia as MNES under the EPBC Act.

Environmental mitigation measures would be in place to safeguard migratory birds protected under international conventions.

4.6 Waste management policies

4.6.1 National Waste Policy

The *National Waste Policy: Less Waste, More Resources* (NWP) (DoE, 2015a), agreed by all Australian Environment Ministers in 2009, provides for a coherent, efficient and environmentally responsible approach to waste management in Australia. The policy provides waste management and resource recovery direction to 2020. The aims of the NWP are to:

- Avoid the generation of waste, reduce the amount of waste (including hazardous waste) for disposal.
- Manage waste as a resource.
- Ensure that waste treatment, disposal, recovery and re-use is undertaken in a safe, scientific and environmentally sound manner.
- Contribute to the reduction in greenhouse gas emissions, energy conservation and production, water efficiency and the productivity of the land.

The NWP includes hazardous wastes and substances in the municipal, commercial and industrial, construction and demolition waste streams and covers gaseous, liquid and solid wastes. Radioactive waste is excluded. The policy sets directions in six key areas and identifies 16 priority strategies that would benefit from a national or coordinated approach. The strategies focus on (but are not limited to) sustainability, collaboration, reducing health and safety risks, better packaging management and classification of wastes, reduction in biodegradable wastes sent to landfill, services to remote and regional communities and responsibility to international obligations.

The Proposal would be developed with consideration of the NWP. If implemented, the Proposal would support the following key areas of the policy:

- **Improving the market** – efficient and effective Australian markets operate for waste and recovered resources, with local technology and innovation being sought after internationally.
- **Reducing hazard and risk** – reduction of potentially hazardous content of wastes with consistent, safe and accountable waste recovery, handling and disposal.
- **Tailoring solutions** – increased capacity in regional, remote and Indigenous communities to manage waste and recover and re-use resources.

4.6.2 Western Australian Waste Strategy

The *Western Australian Waste Strategy: 'Creating the Right Environment'* (Western Australian Waste Authority, 2012) is the primary strategy for waste management and resource recovery in WA. The five objectives of the strategy are as follows:

- **Strategy objective 1** – initiate and maintain long-term planning for waste and recycling processing, and enable access to suitably located land with buffers sufficient to cater for the State's waste management needs.
- **Strategy objective 2** - enhance regulatory services to ensure consistent performance is achieved at landfills, transfer stations and processing facilities.
- **Strategy objective 3** - develop best practice guidelines, measures and reporting frameworks and promote their adoption.
- **Strategy objective 4** - use existing economic instruments to support the financial viability of actions that divert waste from landfill and recover it as a resource.
- **Strategy objective 5** - communicate messages for behaviour change and promote its adoption, and acknowledge the success of individuals and organisations that act in accordance with the aims and principles in the strategy and assist in its implementation.

If implemented, the Proposal would support the objectives of the WA Waste Strategy (particularly Strategy objective 1) by planning for the long-term storage and isolation of hazardous, intractable and LLW that cannot be recycled or recovered, to cater for WA's waste management needs.

4.6.3 Acceptance of interstate waste

There is no formal EPA policy in relation to the acceptance of waste from outside of WA. A restriction on the acceptance of waste from outside WA applies to the IWDF but this arises from a proponent commitment only.

4.7 Other policies relevant to the Proposal

A number of strategic plans have been prepared for the Goldfields-Esperance region. These plans are outlined below and include:

- *Goldfields-Esperance Strategic Development Plan 2011–2021* (Regional Development Australia Goldfields-Esperance, the Goldfield-Esperance Development Commission and the Goldfields Voluntary Regional Organisation of [Local Government] Councils, 2012).
- *Goldfields-Esperance Regional Planning Strategy* (Western Australian Planning Commission, 2000).
- *Goldfields-Esperance Regional Investment Blueprint* (Goldfields-Esperance Development Commission, 2016).
- *Goldfields-Esperance Workforce Development Plan 2013–2016* (Department of Training and Workforce Development, 2012).
- *Workforce Futures for the Goldfields-Esperance Region* (Department of Education and Training State Training Board, 2008).

The Proposal would positively contribute to several of the initiatives put forward within the above plans. It would result in significant social and economic benefits for the region including providing local employment opportunities, local training opportunities, Indigenous employment and training opportunities, local business support and encourage investment opportunities and regional development in the Goldfield-Esperance region.

4.7.1 Goldfields-Esperance Strategic Development Plan 2011–2021

The *Goldfields-Esperance Strategic Development Plan 2011–2021* is the product of an extensive collaboration between Regional Development Australia Goldfields-Esperance, the Goldfield-Esperance Development Commission and the Goldfields Voluntary Regional Organisation of (Local Government) Councils (July 2012). It establishes foundations for advancing long-term development in the region while identifying priority initiatives for the current decade.

The plan is built on addressing the needs of the region, which include meeting infrastructure needs, developing social infrastructure, addressing workforce requirements, addressing environmental challenges and diversifying the economic base. To address these needs, the critical aspirations for the region are:

- Effective and efficient infrastructure to meet regional demand.
- Attraction and retention of the required workforce.

- A quality of life that attracts and retains people in the region.
- Development of renewable energy sources for the future.
- Regional decisions to address regional challenges.

4.7.2 Goldfields-Esperance Regional Planning Strategy

The *Goldfields-Esperance Regional Planning Strategy* developed by the Western Australian Planning Commission (July 2000) identifies land use needs and growth requirements for the Goldfields-Esperance region. The following represent the broad principles of the strategy:

- **Community principle**: To respond to social changes and facilitate the creation of vibrant, accessible, safe and self-reliant communities.
- **Infrastructure principle**: To facilitate strategic development by ensuring that land use, transport and public utilities are mutually supportive.
- **Environmental principle**: To protect and enhance the key natural and cultural assets of the region and deliver to all residents a high quality of life which is based on environmentally sustainable principles.
- **Economic principle**: To actively assist in the creation of regional wealth, support the development of new industries and encourage economic activity in accordance with sustainable development principles.
- **Regional development principle**: To assist in the development of the region by taking account of the regions' special assets and accommodating its individual requirements.

4.7.3 Goldfields Esperance Regional Investment Blueprint

The *Goldfields Esperance Regional Investment Blueprint* prepared by the Goldfields-Esperance Development Commission (March 2016) is a roadmap for the future social and economic growth and prosperity of the region to 2050 (and beyond). The following regional priorities are outlined in the blueprint:

- Enhancing regional living (building healthy educated and inclusive communities, supporting skills development and employability, conserving our natural environment, and improving services in regional centres).
- Enabling infrastructure (expanding and improving infrastructure to move, transport and connect digitally as well as providing new energy sources and accessible reliable utilities).
- Fostering an innovative economy (focusing on investment, market development, creativity and innovation).

4.7.4 Goldfields-Esperance Workforce Development Plan 2013–2016

The *Goldfields-Esperance Workforce Development Plan 2013–2016* was developed by the Department of Training and Workforce Development (2012). The plan aims to build, attract and retain a skilled workforce to meet the economic needs of the Goldfields-Esperance region. The following represent the goals of the plan:

- **Strategic goal 1**: Increase participation in the workforce particularly among the underemployed and disengaged, mature aged workers, Aboriginal and Torres Strait Islander and other under-represented groups.
- **Strategic goal 2**: Supplement the WA workforce with skilled migrants to fill employment vacancies unable to be filled by the local workforce and address those factors which support a growing workforce.
- **Strategic goal 3**: Attract workers with the right skills to the WA workforce and retain them by offering access to rewarding employment and a diverse and vibrant community and environment to live in.
- **Strategic goal 4**: Provide flexible, responsible, and innovative education and training which enables people to develop and utilise the skills necessary for them to realise their potential and contribute to WA's prosperity.
- **Strategic goal 5**: Plan and coordinate a strategic WA Government response to workforce development issues in WA.

4.7.5 Workforce futures for the Goldfields-Esperance Region

The *Workforce Futures for the Goldfields-Esperance Region* was prepared by the Department of Education and Training State Training Board (2008) in a response to serious labour shortages across a range of sectors and occupational groups that threatened to constrain economic growth and prevent the region from fully meeting its potential. The project culminated in the preparation of a workforce plan. The plan focuses on three key themes:

- Attraction and retention of jobs.
- Education and training.
- Regional monitoring, evaluation and plan implementation.

4.8 Policy, guidelines and codes of practice

Applicable guidelines and codes of practices that are relevant to environmental management of the proposal are outlined in Table 4-3.

Table 4-3 Relevant guidelines and codes of practice

Key Environmental Factor	Relevant policy, guidelines and codes of practice (see the ESD in Appendix A.1)
Flora and vegetation	*Relevant EPA policies and guidelines* • *Checklist for documents submitted for EIA on marine and terrestrial biodiversity.* • *Position Statement 2: Environmental Protection of Native Vegetation in Western Australia, Perth, Western Australia* (EPA, 2000). • *Position Statement 3: Terrestrial Biological Surveys as an Element of Biodiversity Protection, Perth, Western Australia* (EPA, 2002). • *Guidance Statement No. 51: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia June 2004, Perth, Western Australia* (EPA, 2004a). • *Environmental Offsets Policy, Perth, Western Australia* (Government of Western Australia, 2011). • *Environmental Offsets Guidelines, Perth, Western Australia* (Government of Western Australia, 2014). • *Technical Guide – Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA and Department of Parks and Wildlife, 2015). *Relevant Commonwealth policies and guidelines* • *Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy* (DSEWPAC*, 2012). • *Outcomes-based Conditions Policy Environment Protection and Biodiversity Conservation Act 1999* - Draft (Commonwealth of Australia, 2015). *Technical guideline* • *A review of existing Australian radionuclide activity concentration data in non-human biota inhabiting uranium mining environments. Technical Report 167* (ARPANSA, 2014a).
Terrestrial environmental quality	*Relevant EPA policies and guidelines* • *Guidance for the Assessment of Environmental Factors. Rehabilitation of Terrestrial Ecosystems. No. 6* (EPA, 2006). • *Environmental Protection Bulletin No. 19 EPA involvement in mine closure* (EPA, 2015b). • *Guidelines for Preparing Mine Closure Plans, Perth, Western Australia* (EPA and DMP, 2015).

Key Environmental Factor	Relevant policy, guidelines and codes of practice (see the ESD in Appendix A.1)
	Relevant Commonwealth policies and guidelines • *National Waste Policy: Less Waste, More Resources* (Department of the Environment, Water, Heritage and the Arts, 2009). • *Outcomes-based Conditions Policy Environment Protection and Biodiversity Conservation Act 1999 – Draft* (Commonwealth of Australia, 2015). *Technical guideline* • *Leading practice sustainable development program for the mining industry* (DRET^, 2008).
Fauna	*Relevant EPA policies and guidelines* • *EPA Position Statement No. 3 Terrestrial Biological Surveys as an Element of Biodiversity Protection* (EPA, 2002). • *Guidance Statement No. 56 Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia June 2004* (EPA, 2004b). • *Guidance Statement No. 20 Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment* (EPA, 2009). • *Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment. Technical report of the Environmental Protection Authority and the Department of Environment and Conservation* (Hyder et al., 2010). • *Environmental Offsets Policy, Perth, Western Australia* (Government of Western Australia, 2011). • *Environmental Offsets Guidelines, Perth, Western Australia* (Government of Western Australia, 2014). *Relevant Commonwealth policies and guidelines* • *Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy* (DSEWPAC, 2012). • *Guide for Radiation Protection of the Environment. RPS G-1* (ARPANSA, 2015). • *National Recovery Plan for Malleefowl Leipoa ocellata* (Benshemesh, 2007). • *Survey Guidelines for Australia's Threatened Birds. EPBC Act survey guidelines 6.2* (Department of the Environment, Water, Heritage and the Arts, 2010). • *Outcomes-based Conditions Policy Environment Protection and Biodiversity Conservation Act 1999 – Draft* (Commonwealth of Australia, 2015).

Key Environmental Factor	Relevant policy, guidelines and codes of practice (see the ESD in Appendix A.1)
Inland waters environmental quality	*Relevant EPA policies and guidelines* • *Guidance for the Assessment of Environmental Factors. Rehabilitation of Terrestrial Ecosystems. No. 6* (EPA, 2006). • *Guidelines for Preparing Mine Closure Plans, Perth, Western Australia* (EPA and DMP, 2015). • *Environmental Protection Bulletin No. 19 EPA involvement in mine closure* (EPA, 2015b). *Relevant Commonwealth policies and guidelines* • *Outcomes-based Conditions Policy Environment Protection and Biodiversity Conservation Act 1999 – Draft* (Commonwealth of Australia, 2015).
Human health	*Relevant EPA policies and guidelines* • *Guidance Statement No. 55: Guidance for the assessment of environmental factors – Implementing best practice in proposals submitted to the environmental impact assessment process, Perth, Western Australia* (EPA, 2003). • *Guidance Statement No. 3 Separation Distances between Industrial and Sensitive Land Uses* (EPA, 2005). • *Guidance for the Assessment of Environmental Factors. Rehabilitation of Terrestrial Ecosystems. No. 6* (EPA, 2006). • *Consideration of environmental impacts from noise* (EAG13) (EPA, 2014a). • *Guidelines for Preparing Mine Closure Plans, Perth, Western Australia* (EPA and DMP, 2015). • *Environmental Protection Bulletin No. 19 EPA involvement in mine closure* (EPA, 2015b). *Relevant Commonwealth policies and guidelines* • *Outcomes-based Conditions Policy Environment Protection and Biodiversity Conservation Act 1999 – Draft* (Commonwealth of Australia, 2015). • *National Environment Protection (Movement of Controlled Waste between States and Territories) Measure 1998 (as amended)* (NEPC[+], 1998a). *National technical guidelines* • *Code of Practice for the near-surface disposal of radioactive waste in Australia* (NHMRC, 1992). • *Classification and Disposal of Radioactive Waste in Australia – Consideration of Criteria for Near Surface Burial in an Arid Area. Technical Report Series No. 152* (ARPANSA, 2010). • *Code for the Safe Transport of Radioactive Material. RPS C-2* (ARPANSA, 2014b).

Key Environmental Factor	Relevant policy, guidelines and codes of practice (see the ESD in Appendix A.1)

	• *Leading practice sustainable development program for the mining industry* (DRET, 2008).
	• *Australian Drinking Water Guidelines* (NHMRC, 2011 as amended 2016).
	State technical guidelines
	• *Landfill Waste Classification and Waste Definitions* (DEC, 1996 as amended 2009).
	• *Assessment and Management of Contaminated Sites* (DER[~], 2014).
	• *Managing naturally occurring radioactive material (NORM) in mining and mineral processing - Guidelines:*
	  o *NORM-4.1 Controlling dust strategies.*
	  o *NORM-5 Dose assessment* (DMP, 2010).
	• *Guidance Note on Public Health Risk Management of Asbestiform Materials Associated with Mining* (Department of Health, 2013).

Heritage	*Relevant EPA policies and guidelines* • *Guidance Statement No. 41 Assessment of Aboriginal Heritage* (EPA, 2004c). *Relevant Commonwealth policies and guidelines* • *Outcomes-based Conditions Policy Environment Protection and Biodiversity Conservation Act 1999 – Draft* (Commonwealth of Australia, 2015). *Relevant technical guideline* • *Aboriginal Heritage – Due Diligence Guidelines. Version 3.0.* (DAA[#] and DPC[&], 2013).
Offsets	*Relevant EPA policies and guidelines* • *Environmental Offsets Policy, Perth, Western Australia* (Government of Western Australia, 2011). • *Environmental Offsets Guidelines, Perth, Western Australia* (Government of Western Australia, 2014). • *Environmental Protection Bulletin No. 1 - Environmental offsets* (EPA, 2014b). *Relevant Commonwealth policies and guidelines* • *Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy* (DSEWPAC, 2012).

Key Environmental Factor	Relevant policy, guidelines and codes of practice (see the ESD in Appendix A.1)
	• *Outcomes-based Conditions Policy Environment Protection and Biodiversity Conservation Act 1999 – Draft* (Commonwealth of Australia, 2015).
Rehabilitation and decommissioning	*Relevant EPA policies and guidelines* • *Guidance for the Assessment of Environmental Factors. Rehabilitation of Terrestrial Ecosystems. No. 6* (EPA, 2006). • *Guidelines for Preparing Mine Closure Plans* (EPA and DMP, 2015). • *Environmental Protection Bulletin No. 19 EPA involvement in mine closure* (EPA, 2015b). *Relevant Commonwealth policies and guidelines* • *Outcomes-based Conditions Policy Environment Protection and Biodiversity Conservation Act 1999 - Draft* (Commonwealth of Australia, 2015). *Relevant technical guideline* • *Leading practice sustainable development program for the mining industry* (DRET, 2008).

** Department of Sustainability, Environment, Water, Population and Communities*

^ Department of Resources Energy and Tourism

+National Environment Protection Council

~Department of Environment Regulation

 # Department of Aboriginal Affairs

& Department of the Premier and Cabinet

Part B

Proposal Details and Engagement

5 PROPOSAL DEFINITION

5.1 Proposal overview and key characteristics

5.1.1 Introduction

The proponent is seeking environmental approval to construct and operate a dual revenue business. The first aspect of the dual revenue model relates to the mining, processing and export of kaolin. The second aspect relates to the long-term storage, recovery and permanent isolation of hazardous and intractable wastes in mine voids. If approved, the Proposal would be located in remote WA (Figure 1-1 and Figure 1-3).

The placement of these wastes in a near surface repository, based on international best practice techniques, would isolate the wastes from the biosphere over geological time.

As descried in the ESD, work excluded from this Proposal includes the transport of waste materials to the Sandy Ridge Facility. This aspect of the Proposal would be addressed under the appropriate legislation, guidelines and codes.

Any low level radioactive waste transport would be carried out in accordance with the *Australian Code for the Transport of Dangerous Goods by Road & Rail* as class 7 Dangerous Goods if it is being transported as a consignment carrying additional classes of Dangerous Goods. In certain circumstances, radioactive wastes may need to be transported as “exclusive use” consignments in accordance with the ARPANSA *Code for the Safe Transport of Radioactive Material* (2014) which adopts the International Atomic Energy Agency *Regulations for the Safe Transport of Radioactive Material 2012 Edition (SSR-6).*

It would be the responsibility of appropriately licensed reputable logistics companies with trained drivers, roadworthy vehicles, and strict transport plans that include a detailed 24 hour and 7 day a week emergency response management plan in the unlikely event of an emergency. Transport to site would only occur with the proponent’s approval (the proponent’s QA/QC system).

5.1.2 Location

The Proposal is located approximately 75 km north-east of Koolyanobbing, WA (refer to Figure 1-1). Access is via a 95 km length of the IWDF access road that extends northward from Great Eastern Highway; a 4.5 km westwards section and a 5.3 km northwards section of site access road into the proposed development envelope (refer to Figure 1-4).

There are no sensitive environmental or human receptors within 5 km of the proposed cell area. The nearest operation is the IWDF located approximately 5.5 km to the east, which operates on a campaign basis and does not have permanent residents. The nearest permanent mining camp is the Carina Iron Ore Mine Accommodation Village located approximately 52 km to the south of the proposed development envelope (refer to Figure 1-4).

5.1.3 Kaolin

The Proposal would produce up to 40,000 tpa of refined kaolin for ceramic paint and other industrial uses (Plate 5-1). The ore would be processed via an onsite wet processing plant (refer to Section 5.4.4 for more information) and the kaolin products would be transferred from Sandy Ridge to the domestic market or to Fremantle Port for export overseas. All overburden (sandy clay, laterite gravel and silcrete) would be returned to the cells for use in backfill around buried waste. After a monitoring period the topsoil is returned and the surface revegetated using locally sourced plant material.

Plate 5-1 Ceramic and industrial uses of kaolin

5.1.4 Waste emplacement

The waste aspect of the Proposal involves storage of up to 100,000 tpa or up to 2.5 million tonnes of intractable, hazardous and low level radioactive wastes in the mine voids over a period of 25 years. Wastes would be accepted predominantly from within WA but also accepted from across Australia and from Australia's Exclusive Economic Zone.

Cells would be filled with wastes in layers with multiple sections in each layer. All space between waste packages would be backfilled and compacted to minimise air or void space which may result in settlement. Each layer would be compacted, until approximately 7 m below the ground surface, where a thick layer of low permeability clay would seal the waste layers to prevent water ingress into the cell.

Following this, compacted gravel and laterite backfill and a clay domed cap would be situated on the top of the cell, to horizontally shed any landing rainfall. At the completion of a subsidence monitoring period, soil would be placed over the domed clay cap to enable re-vegetation. During the waste disposal process a roof canopy would be positioned over the cell to exclude rainfall prior to the capping layer being installed.

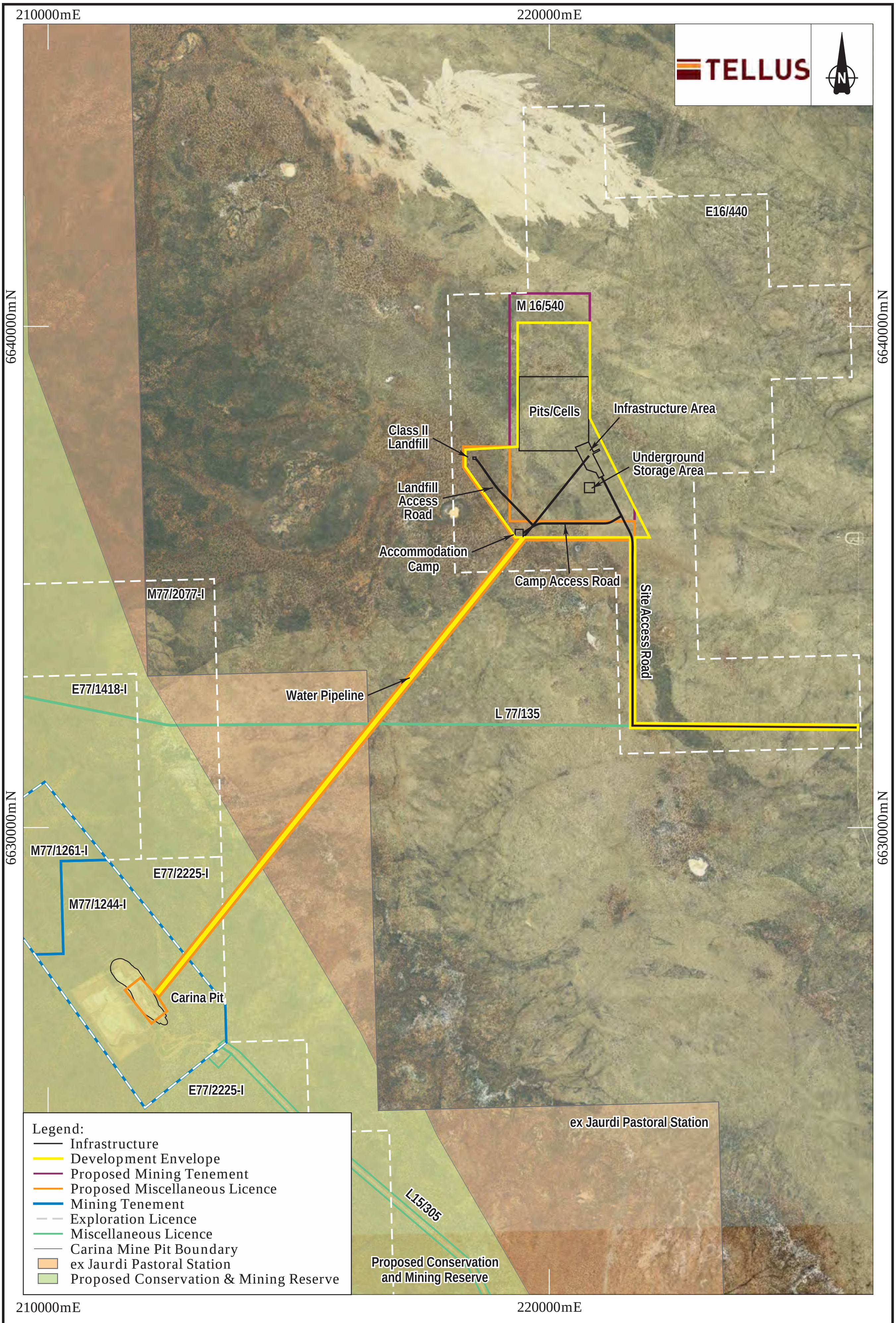
There are some waste types that may be placed in a cell without a roof, as the materials being placed are not immediately leachable, such as some contaminated soils and contaminated railway sleepers. Any such cell construction would be designed with a drainage sump to enable pumping-out of any direct precipitation whilst the cell is open. In addition, any potential stormwater surface flows would be diverted away from the cells by bund walls or levee banks.

5.1.5 Key Proposal characteristics

In accordance with *Environmental Assessment Guideline for Defining the Key Characteristics of a Proposal* (EAG1) (EPA, 2012), the key characteristics of the Proposal are defined in Table 5-1.

Table 5-1 Key Proposal characteristics

Summary of the Proposal		
Proposal title	Sandy RidgeFacility.	
Proponent name	Tellus Holdings Ltd.	
Short description	The Proposal is to develop a kaolin open cut and use the voids resulting from mining for the secure storage, recovery and permanent isolation of hazardous, intractable waste and low level radioactive waste using an international best practice storage and isolation safety case. The Proposal is located approximately 75 km north-east of Koolyanobbing, WA (Figure 1-1).	
PHYSICAL ELEMENTS		
Element	**Location**	**Proposed Extent Authorised**
Pits/Cells	Figure 1-3	Clearing no more than 202.3 ha within 1004.2 ha proposed development envelope.
Mine infrastructure	Figure 1-3	Clearing no more than 17.2 ha within 1004.2 ha proposed development envelope.
Accommodation camp	Figure 1-3	Clearing no more than 2.5 ha within 1004.2 ha proposed development envelope.
Class II landfill	Figure 1-3	Clearing no more than 0.25 ha within 1004.2 ha proposed development envelope.
Future technology park	Figure 1-3	Clearing no more than 4 ha within 1004.2 ha proposed development envelope.
Access roads	Figure 1-4	Clearing no more than 22.2 ha within 1004.2 ha proposed development envelope.
Water pipeline	Figure 5-1	Clearing no more than 27.6 ha within 1004.2 ha proposed development envelope.
Total disturbed area		Clearing a maximum of 276.05 ha within 1004.2 ha proposed development envelope.
OPERATIONAL ELEMENTS		
Element	**Location**	**Proposed Extent Authorised**
Ore Processing	Kaolin Plant, Figure 1-3, coordinates: 220800mE, 6637520mN	Kaolin plant design capacity per annum 40,000 t. Maximum amount disposed 1,000,000 t over a 25-year period
Class IV and Class V waste disposal	Pits/Cells, Figure 1-3 coordinates: 219920mE, 6638195mN	Disposal of no more than 100,000 tpa. Average amount per annum 66,000 t. Maximum amount disposed 2,500,000 t over a 25-year period.
Class II Landfill for waste generated on the site	Class II Landfill, Figure 1-3 coordinates: 218507mE, 6637370mN	Disposal of no more than 500 tpa.
Water use	Water source shown in Figure 5-1 coordinates: 220770mE, 6637430mN	0.18 gigalitres per annum sourced from water tanks onsite that are supplied via a water pipeline from the Mineral Resources Carina Iron Ore Mine.



0 1.5km
Scale 1:100,000
MGA94 (Zone 51)

CAD Ref: g2294_PER_05_01.dgn
Date: November 2016 | Rev: J | A4

Aurora environmental

Author: C. Dorrington | AE Ref: THO2014-003
Drawn: CAD Resources ~ www.cadresources.com.au
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Sandy Ridge Facility

Water pipeline route

Public Environmental Review

Figure:
5-1

5.2 Land use, ownership and tenure, zoning

5.2.1 Current land use

The proposed development envelope is on unallocated Crown land managed by the WA Government, with no current land use or occupation. The proponent holds an exploration licence (E16/440) over 5930 ha of land which has been explored since 2013. The proposed development envelope covers 1004.2 ha (17%) of the exploration lease (refer to Figure 5-2).

5.2.2 Ownership and tenure

The proposed development envelope is located on Crown Land. As the mining and waste disposal aspects would occur simultaneously on the same land, the proponent would require co-existing tenure for each of its mining and non-mining activities.

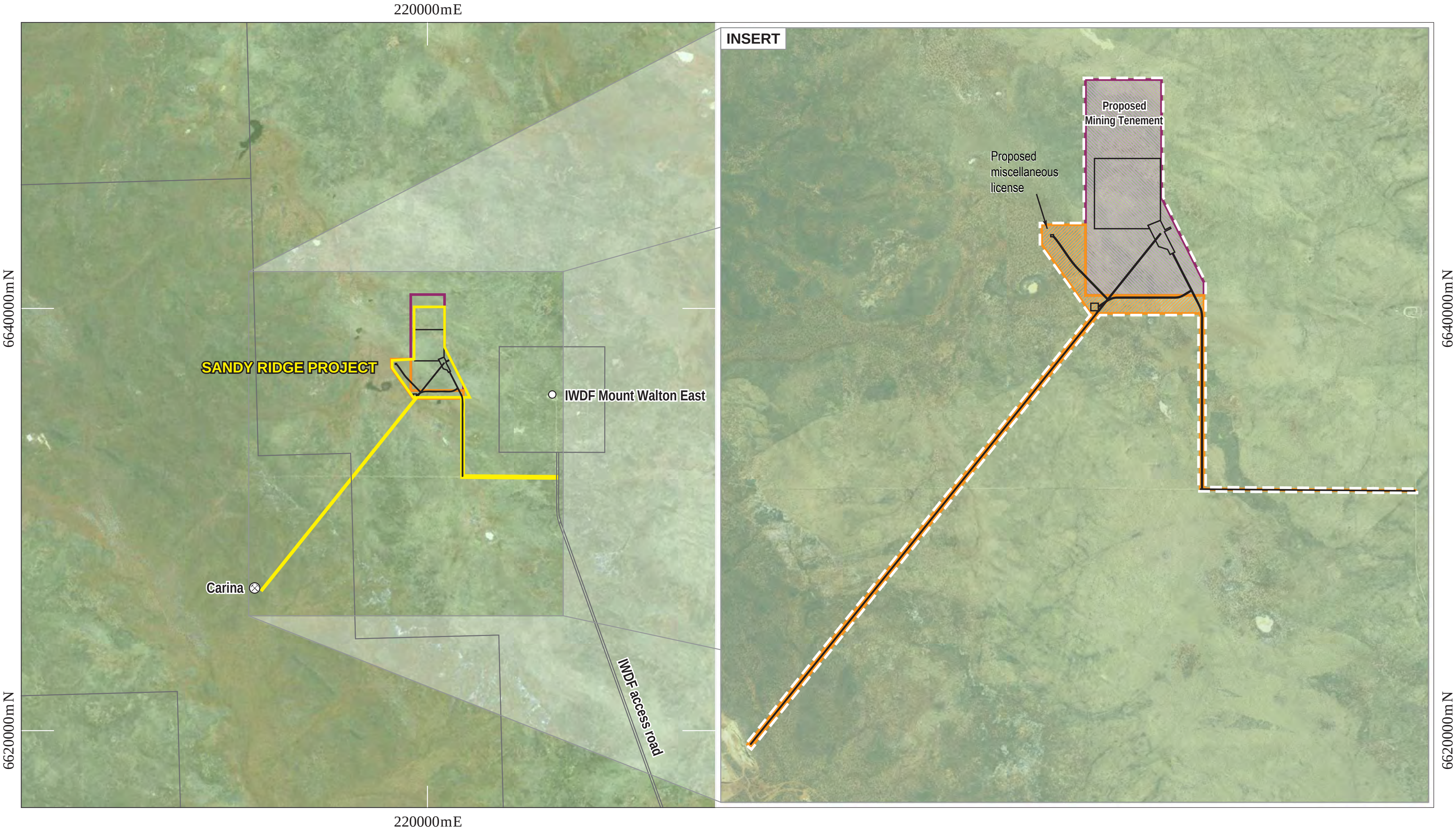
For the purposes of mining activities, would access the land through a mining lease (M16/540) and conduct other mining related activities under miscellaneous licences issued under the *Mining Act 1978* (refer to Figure 5-2). The proponent would also apply for a general-purpose lease for supporting activities.

To implement the waste disposal aspect of the Proposal, the proponent would be applying for a Crown Lease or Reserve over the proposed development envelope. The lease or reserve term would need to align with the Proposal lifecycle so is expected to be for a term of at least 45 years. Crown easements would be also applied for over linear infrastructure and the proponent would have the right to operate the water pipeline and access roads within these easements. The proponent is continuing discussions with Department of Lands and DMP with a view of achieving an in-principle agreement on the terms of the lease (or reserve) and the financial provisions when the land would be reverted to Crown managed land, most likely in the form of a Managed Reserve.

As Department of Lands is a DMA for the proposal under the EP Act, it is precluded from executing a lease until a Ministerial Statement pursuant to Section 45 of the EP Act is issued allowing the proposal to proceed. An indicative lease area is shown on Figure 5-2. A range of other tenure related approvals, e.g. section 165 order, compulsory acquisition steps and easement matters would also be addressed through further consultation with the DMP and Department of Lands.

5.2.3 Zoning

The Proposal's footprint stretches across two shires, namely the Coolgardie Shire and the Yilgarn Shire. The proponent has had discussions with the Yilgarn Shire who advised there would be no approval required from them, as the only infrastructure within that shire is a water pump station and pipeline. Land that occurs within the Coolgardie shire is zoned 'rural/mining' under the Shire of Coolgardie's Town Planning Scheme No. 4 (TPS4) (refer to Figure 5-2). This zoning is appropriate for the Proposal to be developed, and no scheme amendment is required (pers comm. J O'Brien, Shire of Coolgardie, 16 November 2015). Planning approval for the Proposal through the Shire of Coolgardie would be applied for prior to commencement of construction.



Legend:
- Infrastructure
- Development Envelope
- Proposed Mining Tenement
- Proposed Miscellaneous Licence
- Indicative Reserve Area
- Scheme Zoning - Rural / Mining Area

Notes
- Scheme Zoning supplied by DoP (2015)

TELLUS

N

0 5km

Scale 1:250,000
MGA94 (Zone 51)

CAD Ref: g2294_PER_05_02.dgn

Date: Nov 2016 | Rev: B | A4

Author: C. Dorrington | AE Ref: THO2014-003

Drawn: CAD Resources ~ www.cadresources.com.au
Tel: (08) 9246 3242 ~ Fax: (08) 9246 3202

Sandy Ridge Facility

Landuse, tenure and zoning

Public Environmental Review

Figure:

5-2

5.3 Proposal lifecycle

The proponent is seeking approval and an operating licence for the Proposal for a 25-year period. Following the cessation of mining and waste disposal, rehabilitation and institutional control would follow for a period of time. The typical Proposal life cycle has several key milestones as described below and presented in Figure 5-3:

- **Year 1**: at the completion of year one, the initial mine pit would have been excavated, with ore stockpiled ready for processing and up to 50,000 t of waste placed in the cell. How much waste is placed in the cell may vary due to the initial ramp-up of the business. Once the waste cell is full, the cap is completed and subsidence monitoring of the cell commences.
- **Year 11**: subsidence monitoring finishes on the first cell. Topsoil is respread and seeded, and vegetation established. Vegetation monitoring commences. Other cells completed during the previous decade continue to be monitored for subsidence.
- **Year 21**: vegetation monitoring finishes on the first cell, which is considered rehabilitated. Other cells completed during the previous two decades continue to be monitored for subsidence and vegetation growth.
- **Year 25**: at the completion of year 25, up to 7,250,000 t of ore may have been processed, and up to 2,500,000 t of hazardous, intractable and LLW may have been stored. Unless the proponent wishes to continue operations and an extension of the approval and licence is granted), mining and waste storage would cease. In accordance with the Waste Facility Decommissioning and Closure Plan (WFDCP), the cells would have been backfilled and capped, with various stages of rehabilitation and subsidence monitoring in progress.
- **Year 35**: subsidence monitoring on all cells is completed.
- **Year 45**: relinquishment of tenements under the *Mining Act 1978*. All mining related infrastructure has been decommissioned and surfaces revegetated in accordance with the Mine Closure Plan (MCP). Vegetation monitoring on all cells is completed. The Facility is rehabilitated and infrastructure decommissioned. Transfer of the management of the Facility to the WA Government along with financial provision for the management of the Facility during the institutional control period (ICP).
- **End of ICP**: the state of WA controls the Facility for the ICP (as described in Section 5.13).

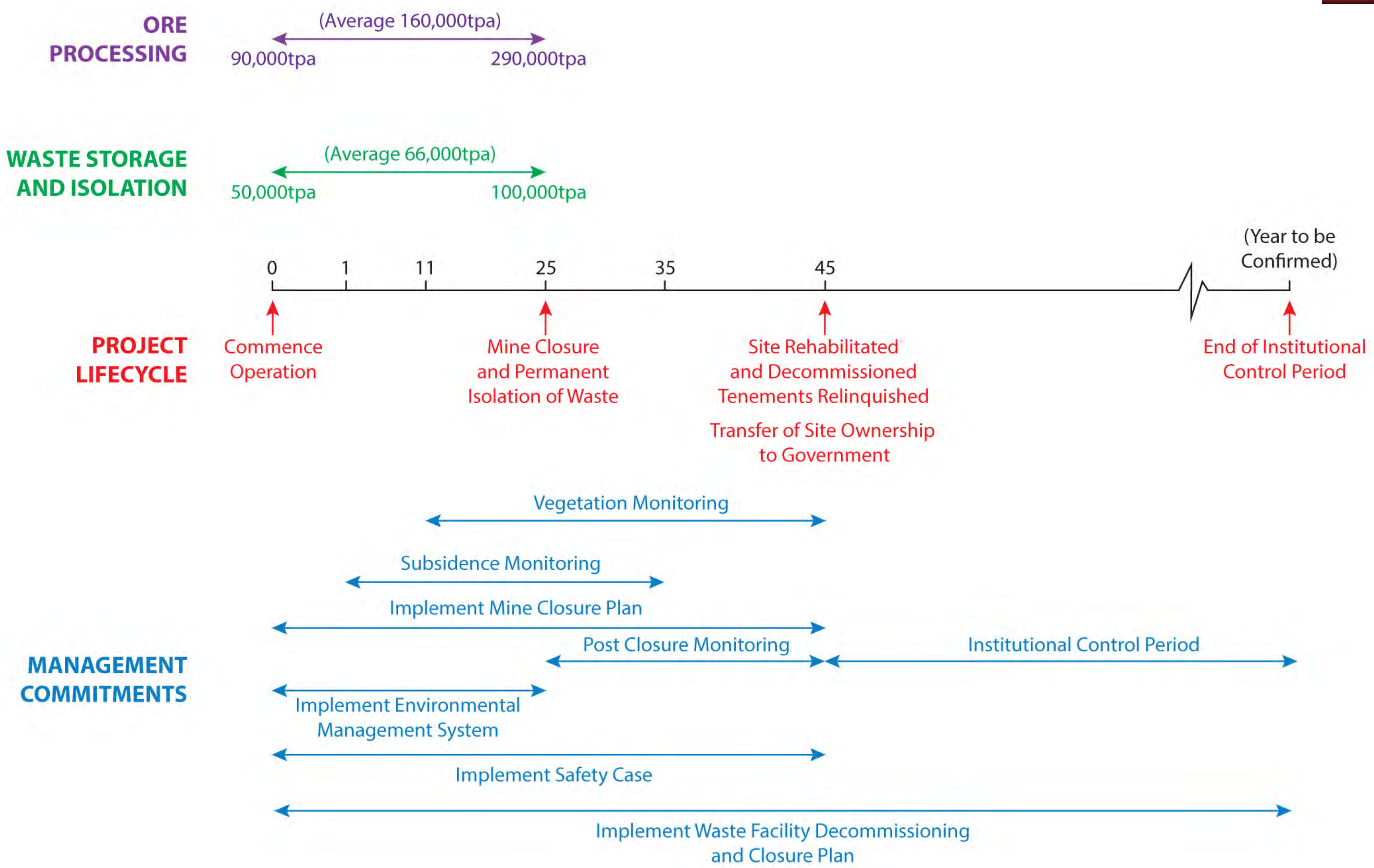


Figure 5-3 Proposed Sandy Ridge Facility lifecycle

5.4 Mining operations

5.4.1 Mineral resource

Exploration drilling has identified a JORC Inferred Mineral Resource of 17.6 million tonnes of kaolinised granite, with 9.5 million tonnes classified as ceramic grade and 8.1 million tonnes classified as paint grade. A 17.6 million tonne resource is likely to provide sufficient ore for at least a 25-year mine life.

5.4.2 Enabling and construction phase

Enabling works would include construction and commissioning of infrastructure. Infrastructure to be constructed and used for the mining operation includes:

- A kaolin processing plant.
- A kaolin ore stockpile area (run of mine [ROM] pad).
- A finished product (kaolin) storage building.
- A laboratory.
- Mining contractor offices and laydown yard including repair and maintenance facilities for earthmoving and plant equipment, saline water ponds, reverse osmosis plant, and an explosive magazine.

Waste related infrastructure to be constructed includes:

- Relocatable waste cell roof canopy and rail system.
- Container hardstand.
- Waste inspection area.
- Radioactive waste warehouse and packaging building.
- A waste laboratory.
- A waste solidification and stabilisation Facility comprising of waste storage, consumables storage and blending and mixing equipment. This is anticipated to be similar in size and layout to a small concrete batching plant.
- Truck and machinery wash-down pad, wash-down water system (including treatment and storage), front gate office, secure site fencing and gatehouse incorporating a computerised weighbridge.

In addition to the construction and commissioning of infrastructure the following activities would be undertaken:

- Construction of the site access roads and internal haul roads.
- Upgrade of the IWDF access road and intersection at Great Eastern Highway.
- Construction of a mobile and permanent accommodation camp.
- Construction of the water pipeline and associated pump station at the Carina Mine pit.
- Construction of administration building and carpark (including offices, first aid, training centre, communications, lunch room, and ablutions).
- Excavation of a trench at the Class II putrescible landfill location and erection of a fence around the landfill.
- Installation of sewage treatment systems.
- Installation of water tanks for raw and potable water.
- Installation of diesel storage tanks, piping reticulation and bowser.
- Installation of drying process fuel storage tanks.
- Installation of switchboards and generators.
- Removal and stockpiling of vegetation and topsoil from infrastructure area and construction of all infrastructure.
- Continued collection of weather data.
- Baseline studies as required by the MCP.
- Construction and commencement of plots for final capping design optimisation and revegetation trials.
- Continued monitoring of groundwater bores.
- Erection of a fence around infrastructure area and pits.

5.4.3 Operations phase

Mining would be carried out in campaigns on a frequency commensurate with the volume of wastes to be isolated. The frequency of mining campaigns is likely to commence at one every year, but the actual frequency is dependent on the depth of mining in each area, the demand for kaolin products and the timing of waste deliveries.

Mining campaigns could be as frequent as twice per year but are typically expected to occur at a rate of one every 12 to 18 months. Depending on the depth of the mine pit, a single waste cell would hold approximately 30,000 to 75,000 tonnes of waste material.

Sequence of pits

Pits would be constructed in sequence along a common alignment whenever possible, before moving to an adjacent alignment and returning in the opposite direction (refer to Figure 5-4).

Figure 5-4 Conceptual layout of mine pits at year 6

Current mine planning is for approximately 25 pits to be constructed. Each mine pit and waste cell would be nominally 120 m long, 60 m wide and 23 m deep (depending on local stratigraphy with a maximum depth of 30 m).

The cell would be covered by a roof canopy, most likely consisting of a steel lattice frame with a fabric covering that would be approximately 65 m wide and 120 m long. This allows the roof canopy to be relocated from one pit to the next on temporary rail tracks. The purpose of the roof is to prevent rainfall from entering the waste cell during the waste storage and isolation operation (refer to Figure 5-5).

There are some waste types which may be placed in a cell without a roof as the materials being placed are not immediately leachable. Any such cell construction would be designed with a drainage sump to enable pumping out of any direct precipitation whilst the cell is open.

Figure 5-5 Conceptual view of pit being mined and pit with roof canopy

A cross section of a typical mine pit is shown in Figure 5-6. Based on exploration drilling results the average overburden (sandy clay, laterite gravel and silcrete) thickness is 6 m. Beneath the overburden, the kaolinised granite (i.e. the mineral resource) is on average 17 m thick (6 m to 23 m depth).

Beneath the kaolin zone is a saprock zone (kaolinite, including some incompletely weathered granite). Below the saprock zone (23.5 m to 28.5 m) is unweathered granite (beyond 28.5 m, typically at 30 m). Note that the transitions between geological units are gradational and identification of boundaries is very subjective.

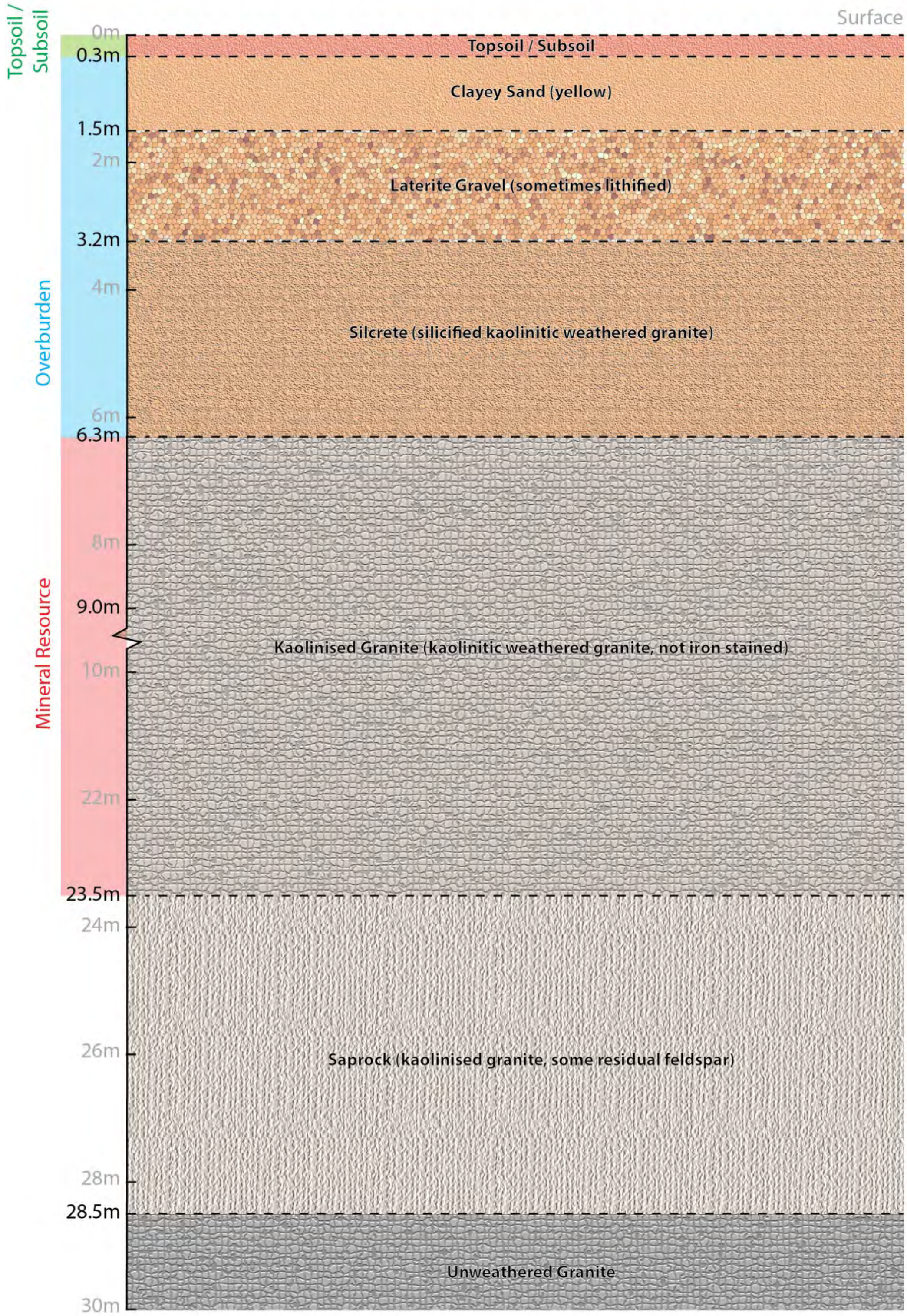


Figure 5-6 Cross section of a typical mine pit

Mining method

The principal mining method would be open cut to extract overburden and kaolin ore. The surface area of each kaolin pit would be cleared of vegetation. Cleared vegetation would be stockpiled and re-used in rehabilitation. The cell would then be opened by excavation of the topsoil, subsurface soil and laterite. Following this, there would be carefully controlled blasting using explosives or continuous mining of the hard, dense silcrete layer that overlays the kaolin, and then removal by excavator and truck.

The kaolin would then be recovered by conventional earthmoving equipment. Based on drilling results, the kaolin ore is very dry at approximately 10% moisture, and is free-digging. The kaolin overburden and ore mining plant fleet is likely to consist of a front-end loader, excavator and articulated dump trucks. The dump trucks would deposit the kaolin in stockpiles adjacent to each pit or the kaolin process plant. Overburden would be stockpiled adjacent to the cells in readiness for backfilling (refer to Figure 5-7).

Figure 5-7 Stockpiles adjacent to pits/cells

Separate stockpiles of different grades of kaolin ore would be located adjacent to the kaolin processing plant or each pit.

Excavation to the pit base

The elevation of the base of the pits would vary depending on the location of the mineral resource and the elevation of the top of the saprock. Mine-planning activity would ensure that at least 5 m of kaolinised granite remains in situ between the bottom of the pit and above the top of the unweathered granite.

This would be achieved through mine planning and grade control drilling. The location of each drill hole would be surveyed so that any hole penetrations within the mining pit areas would be known, and any locations where 'over-drilling' below the pit floor elevation has taken place would be carefully backfilled with compacted kaolinitic material. This process would ensure that the drilling activities do not provide preferential pathways in the unweathered granite if in the unlikely event a contaminated plume was ever generated from cells.

Transition from mine pit into waste cell

During mining, the excavation is termed a 'pit', once it is completed and ready for waste storage and isolation activities, it is termed a 'cell'.

In a typical cycle, one new mining pit would be excavated with the mining activities being scheduled to finish just prior to the previous pit (now a waste cell) being completely filled (refer to Figure 5-8). This would minimise the time that a completely mined pit would remain open to the weather. All surfaces within the pit would be graded to manage any precipitation which would run-off to a sump. The sump would be maintained in a dry state by a diesel powered portable pump, discharging to a pond at surface level.

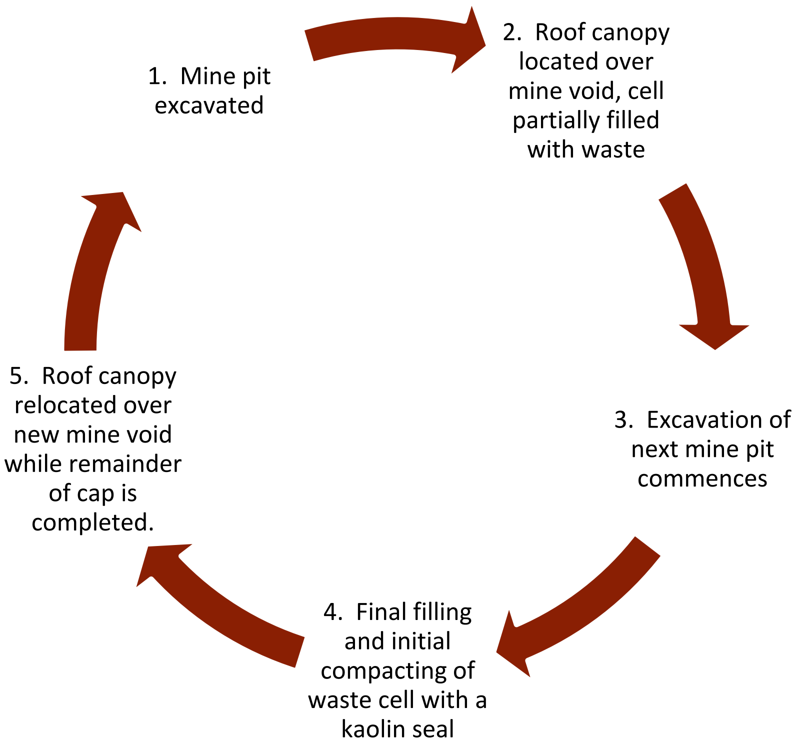


Figure 5-8 Normal sequence of mining and waste isolation

As soon as the last waste placement has taken place in a cell, the final filling and compacting of the waste cell cap would commence. Upon completion of the first 0.3 m of the lower compacted kaolin seal (grading to a run-off sump and pump), the portable roof canopy would be relocated over the newly excavated mine pit, which then becomes a waste cell.

The cycle then repeats as required. Should the kaolin production and waste disposal activities increase in scale due to market demand, the frequency of this cycle would simply increase.

5.4.4 Kaolin process description

A wet mineral processing circuit, as described further below, would be implemented to refine the kaolin product from the ore. A typical kaolin plant process flow diagram is provided in Figure 5-9. ROM feed material is recovered from the ore stockpile by a front-end loader and placed into a hopper feeding a trommel.

Material is screened and any oversize would be stockpiled for use in backfilling cells. Water is added at this point to produce a slurry which then undergoes a process of washing and hydro-cycloning to reject all quartz sand particles and recover the fine (<45 micron) kaolin clay particles. Varying portions of coarser kaolin particles are rejected in the hydro-cyclone stage to control the product properties depending upon the grade of product being produced at that time. The refined kaolin slurry is dewatered by filter press for drying in a gas-fired kiln before being packaged in bulk-bags or paper sacks on pallets. Some kaolin products may be further dried and pulverised into a dry powder before bagging.

Bagged product would be stored onsite pending quality assurance checks and to facilitate optimal transport arrangement. The on-site storage also provides buffer capacity between production and dispatch in the event of interruptions to either activity.

Forklifts would handle the bags from the filling stations in the plant, and for loading of stored bags onto trucks or into sea containers.

Waste streams from the kaolin processing plant consist of ROM oversize, waste quartz sand and de-watered coarse kaolin and very fine sand. All of these materials are used for backfill in the waste cell. The washed quartz sand is stockpiled on a drainage pad to recover and recycle process water and to ensure that the sand's moisture content is optimal for compaction. Some sand and screen oversize would be used for maintaining internal haul roads. To meet waste storage scheduling requirements some of these materials would need to be stockpiled close to the active waste cell for some portion of the year.

The only chemical which might be required for mineral processing is a small quantity of sodium hydroxide, to counter the natural acidity of the kaolin ore. Only fresh water is used in the circuit. The fuel for the dryer is likely to be Liquefied Petroleum Gas (LPG), as this is clean burning and would not produce soot or sulphur oxides which might affect the quality of the kaolin.

Imported bentonite clay may be added in small quantities to improve some end-use properties of the kaolin.

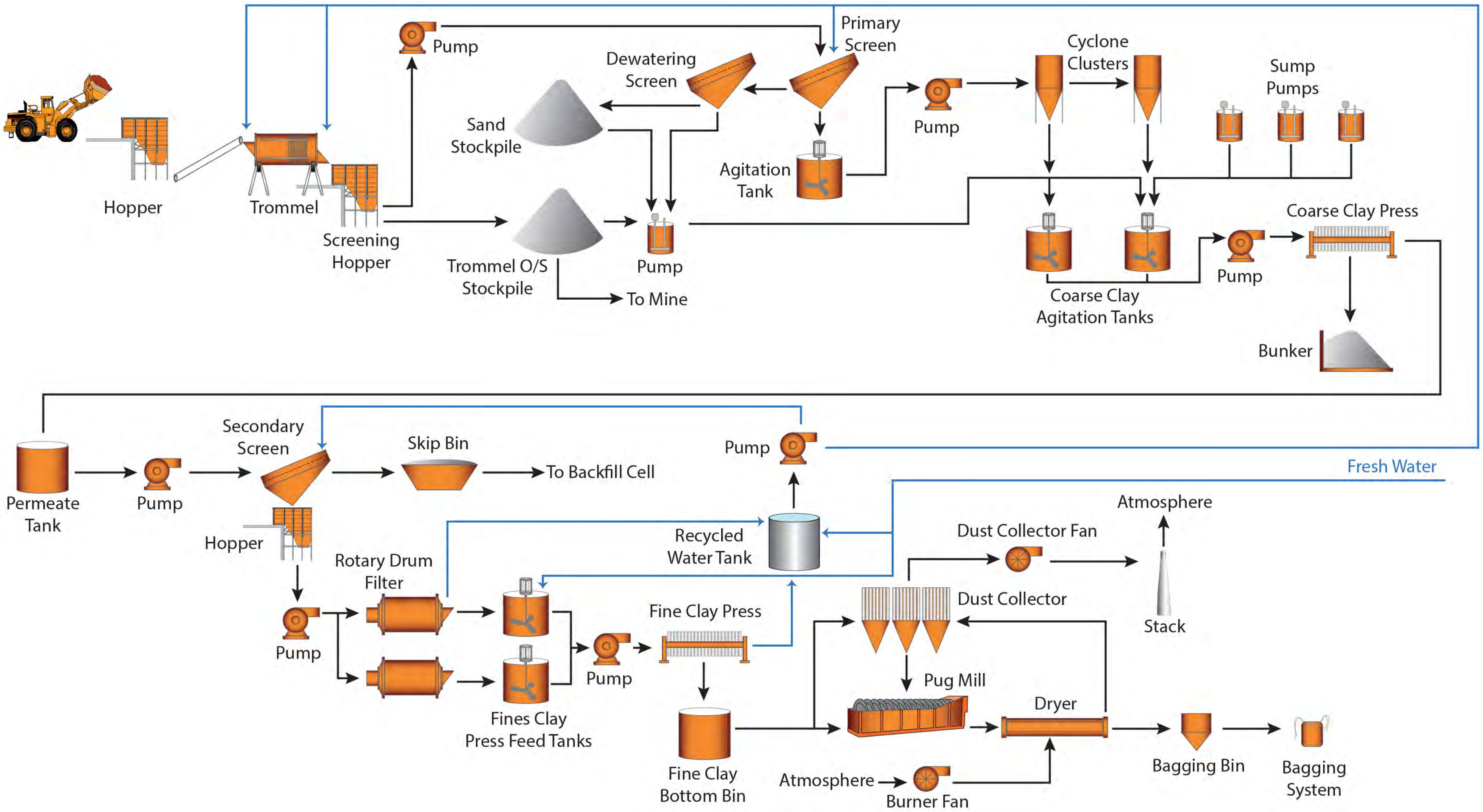


Figure 5-9 Conceptual process flow diagram

5.4.5 Transport of kaolin products from Sandy Ridge

Kaolin products would be transported from Sandy Ridge to markets both domestically and internationally. International exports are likely to depart in sea-container lots via Fremantle Port. The route departing the site would commence along the IWDF access road to the intersection with Great Eastern Highway.

Transport options are still being evaluated, but trucking is the most likely mode of transport. Export kaolin trucks then continue west along Great Eastern Highway to the outskirts of Perth. The route within Perth and to the port for full containers would depend upon which company is selected to provide intermediate warehousing and container services. If not already packed into containers at Sandy Ridge, transported bagged kaolin is packed into containers for export through the Fremantle Inner Harbour container terminals.

The total distance of the journey from Sandy Ridge to Fremantle Port is approximately 750 km. It is proposed an average of eight trucks would carry kaolin per week, and based on 50 weeks of truck movements, 400 trips per year would operate along the route.

5.5 Waste operations

What is hazardous waste?

Hazardous waste in Australia is regulated by the states and territories, which variously describe these waste types as controlled, trackable, prescribed, listed or regulated wastes. Hazardous waste is waste that is a management problem by virtue of its toxicity or chemical or physical characteristics which make it difficult to dispose of or treat safely and which is not suitable for disposal in a Class I, II, III or IV landfill, but is suitable in a geological repository (Class V) like the proposed Sandy Ridge Facility.

Overview

The Facilities' primary objective is to provide customers with a licensed Facility that safely allows for the storage, treatment, recovery and permanent isolation of bulk hazardous and intractable chemical waste materials. Some of these materials may be classified as dangerous or hazardous goods, such as those listed wastes under Schedule 1 of the National Environment Protection (Movement of Controlled Waste between States and Territories) or National Environment Protection (Movement of Controlled Waste between States and Territories) Measure 1998 (NEPM) 75.

The Facility may receive Naturally Occurring Radioactive Material (NORM) up to a low level radioactive waste level (LLW) of activity arising mainly from the mining, oil and gas and agricultural fertiliser, smelting industry. The proponent will be applying for a Licence (Controlled Action) to accept NORM up to a LLW level of activity and non-nuclear LLW such as medical isotopes, smoke detectors and sealed industrial sources. For planning purposes, the proponent is assuming a LLW volume of approximately 1%.

Wastes would be accepted from within WA, other Australian states and territories and from Australia's Exclusive Economic Zone.

Australian's are one of the world's highest emitters of hazardous waste on a per capita basis. Most Australian industries and households produce hazardous waste (refer to Figure 5-10 below).

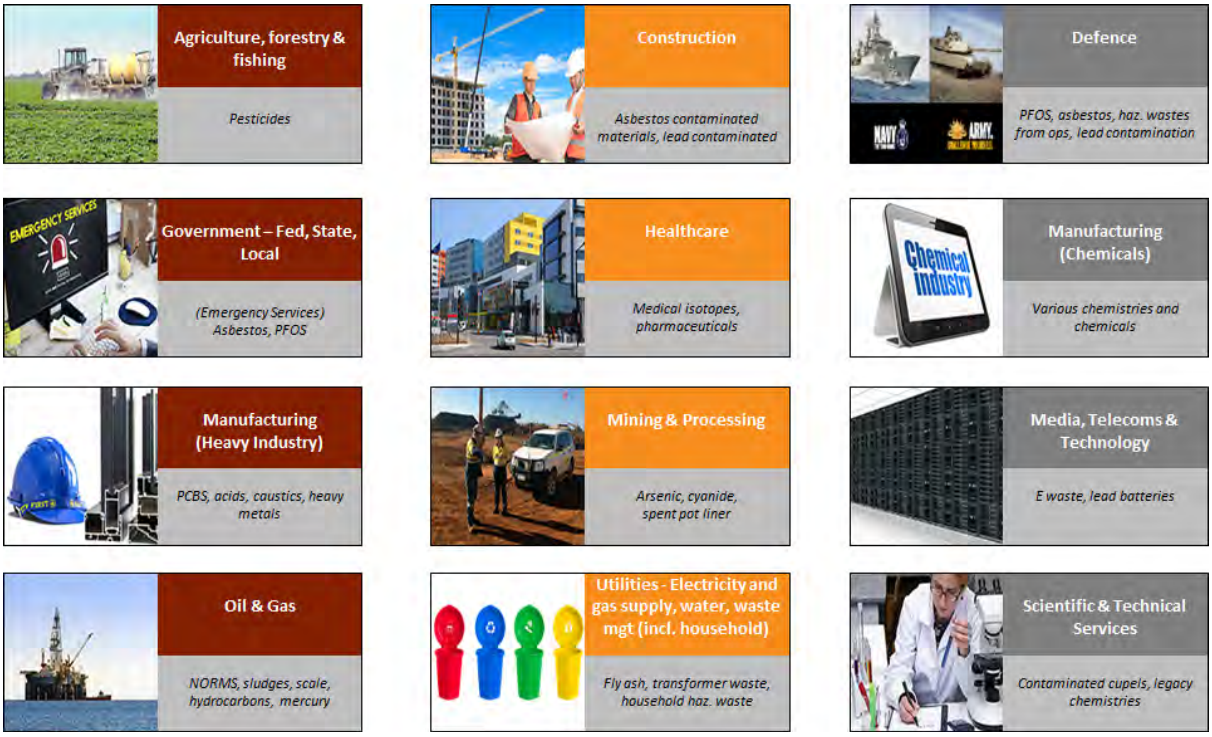


Figure 5-10 Examples of the main household and industry sectors that produce waste

The illustration below (see Figure 5-11) are examples of industrial chemicals uses in Australia.

Figure 5-11 Common industrial chemical uses in Australia that produce wastes accepted for the Proposal

5.5.1 Waste not accepted

Wastes not accepted at the Facility would include:

- Infectious or clinical materials (excluding pharmaceuticals).
- Uncertified waste (waste of unknown composition, or which does not pass the proponent's strict WAC).
- Biodegradable wastes – plant matter which are subject to material biological decomposition (putrescible waste), including vegetable matter (food waste like grease trap and garden waste) and organic materials suitable for Class II or Class III landfill.
- Biodegradable wastes – animal matter – effluent and residues (abattoir effluent, poultry and fish processing wastes), suitable for Class II or Class III landfill.

- Sewage sludge and residues including nightsoil and septic tank sludge.
- Free Liquids – liquid waste is generally excluded, unless it is solidified or packaged in sufficient absorbent material.
- Gases – dangerous goods of Class 2.
- Explosive, flammable, oxidising, corrosive waste – generally excluded, unless it can be safely stabilised and solidified.
- Nuclear waste as defined in the *Nuclear Waste Storage and Transportation (Prohibition) Act 1999* (depleted uranium, enriched uranium, LEU, HEU, Uranium-233 or plutonium). Does not include natural uranium and thorium.
- Radiation waste that may expose members of the public, workers or the environment to dose levels above the dose constraint limits set by the proponent for the operation. This level is typically one per cent level lower than set by the regulators. For example, the proponent has set a limit of 0.3 milli sievert (mSv)/a as dose constrained, which is well below the 1 mSv/a per annum guideline set by ARPANSA. To put this in context, the dose constrained limit equals three chest X-rays per year. One CT cat scan alone is 7 mSv, which is 23 times higher than the exposure dose constraint set by the proponent and seven times higher than the dose limits recommended by ARPANSA.
- Intermediate level and High level radioactive waste (HLW).

As stated above, nuclear waste storage or disposal services would not be provided at the proposed Sandy Ridge Facility. The Propsal has not been nominated as a potential National Radioactive Waste Management Facility. No such nomination is planned and no such nomination would be accepted should it be made by any other party.

5.5.2 Naturally occurring radioactive material

The Facility would be a world's best practice Facility for the storage (retrievable) and permanent isolation (non-retrievable) of chemical waste. However, some wastes also contain levels of naturally occurring radioactive material.

Almost everything in nature has some small amount of natural radioactivity and processing concentrates it. At Sandy Ridge the acceptance criteria identify NORM up to Low Level Waste (LLW) activity content[14] and other LLW such as medical isotopes, smoke detectors, sealed gauges as suitable for storage and disposal in accordance with the safety case (see Table 5-2).

[2] *Classification of Radioactive Waste – RPS20, ARPANSA*

Table 5-2 NORM and LLR wastes accepted on site (surface) and below ground in waste cells

Radioactive wastes[2] (✓ = accepted, × = not accepted)	Accepted on site (surface storage)	Accepted below ground in waste cells
Naturally Occurring Radioactive Material (NORM) ***up to LLW activity levels*** *such as oil and gas industry scale*	✓	✓
Low level Waste (LLW) *such as smoke detectors, exit signs, industrial gauges and medical isotopes*	✓	✓
Intermediate level (ILW) and high level waste (ILW) *such as reprocessed spent nuclear fuel and components with high levels of radioactivity*	×	×
Nuclear waste *from power generation and defense use*	×	×

As stated above, nuclear waste storage or disposal services would not be provided at the proposed Sandy Ridge Facility. The Sandy Ridge Project has not been nominated as a potential National Radioactive Waste Management Facility. No such nomination is planned and no such nomination would be accepted should it be made by any other party.

What is NORM?

According to the Australian Federal Government's ARPANSA 2008 Management of NORM Report (Publication 15), NORM is abundant in the environment.

NORM is widespread in sands, clays, soils and rocks, and many ores and minerals, commodities, products, by-products, recycled residues, and devices used by humans. Although the concentration of NORM in most natural substances is low, any operation in which material is extracted from the earth and processed can potentially concentrate NORM in product, by-product or waste (residue) streams. Examples of NORM are listed in Table 5-3.

How is NORM managed in Australia?

According to ARPANSA, the most common ways of dealing with NORM residues are storage in stockpiles and/or tailings dams, utilisation in landfill, road-fill and building materials, and disposal by near-surface burial. The choice of method should be based on the results of an environmental impact assessment. Any disposal of radioactive waste must be approved by the relevant regulator.

The Facility is being developed as a best practice Facility for the permanent isolation of chemical waste. Some wastes also contain very low levels of naturally occurring radioactive material. Wastes containing NORM that would be accepted include from the power, electronics, ceramics, mining, metals and minerals processing, oil and gas, water and agricultural fertiliser industries.

Table 5-3 Examples of NORM

NORM location	Examples of the industry and materials containing NORM
Sands, clays, soils and rocks, and many ores and minerals	• Aluminium industry – bauxite. • Fertiliser industry – phosphate rock. • Paint, paper and plastics industry – mineral sands titanium bearing minerals (ilmenite, leucoxene and rutile). • Electronics industry – rare earth bearing minerals (monazite and xenotime). • Ceramics industry, refractory materials in the steel industry, the foundry industry and abrasive materials industry – mineral sands zirconium bearing mineral (zircon). • Metals and mineral processing industry – ores containing tin, tantalum, niobium, iron and some copper and gold deposits. • Power generation industry – coal (accumulation of impurities in the fly and bottom ash). • Energy industry – oil and gas up, mid and downstream processing, geothermal energy (scaling in pipes and equipment). • Many of the clays, rocks and ores listed above contain low levels of uranium and thorium impurities that accumulate during processing.
Commodities	• Water treatment and purification industry – Residues resulting from water treatment include flocculation sediments, filter sludge, other sand and sludge, spent ion exchange resins and reverse osmosis cartridges from desalination plants. • Building industry – building materials such as fly ash is used as a concrete extender or in lightweight building blocks; bottom ash is sometimes used as a concrete extender. Phosphogypsum is used in plasterboard, some types of granite rock used on kitchen benches and building materials. • Fertiliser industry – phosphate fertiliser.
Products	Ceramic pigments and glazes (often found in tiled bathrooms, hospitals, swimming pools spread very thin).
By-products	Phosphogypsum (by product from phosphate fertiliser industry), has the same chemical properties as natural gypsum used in fertilizer, plaster, blackboard chalk and wallboards.
Residues with potential for future use	• Fly ash from coal burning (electricity generation). • Red mud from alumina production. • Slags from mineral processing.
Devices used by humans	• Welding rods (thorium-conducts heat efficiently). • Gas mantles (thorium). • Electronic components. • Scrap metal recycling. • Magnesium-thorium alloy in jet engines.

NORM waste acceptance criteria

NORM waste acceptance criteria are derived from the generic levels given in the National Health and Medical Research Council, Code of practice for the near-surface disposal of radioactive waste in Australia (1992) for Category C waste and are such that it safeguards individual dose limits and/or dose constraints (less than 1mSv) would be achieved, and incorporates the parent radionuclide (refer to Table 5-4 for NORM acceptance levels).

Table 5-4 NORM acceptance values

Radioisotope		Bq/g allowed to meet dose constrain
Uranium-238	U-238	500
Plutonium-239	Pu-239	10000
americium 241	Am-241	10000
Thorium-232	Th-232	500
Radium-226	Ra-226	500

Radioactive waste classification

The ARPANSA Radiation Protection Series No. 20 - Classification of Radioactive Waste (2010) sets out non-prescriptive, best practice guidance for classifying radioactive waste in Australia and is based on IAEA General Safety Guide Classification of Radioactive Waste (No. GSG-1) published in 2009. The Safety Guide is qualitative in nature with the intention being that users would have appropriate flexibility to classify their waste in accordance with internationally accepted methods and terminology.

The Australian classification scheme for disposal of radioactive waste is based on the safety of disposal pathways; taking into account the radioactivity level and the time it would take for the radioactivity to decay (half-life). As such, it does not include quantitative values of allowable activity content for each significant radionuclide. Radioactive waste classification within Australia is described in Figure 5-12.

Radioactive waste generated in Australia generally falls within the VSLW, VLLW, and LLW or ILW classifications. Australia does not generate any electricity from nuclear power and therefore currently does not generate any used fuel that would be classified as HLW (ANSTO, 2011).

Approval to accept Intermediate or High Level Waste at the Facility is not being sought. As shown in Figure 5-12, approval to permanently isolate exempt waste to LLW is sought.

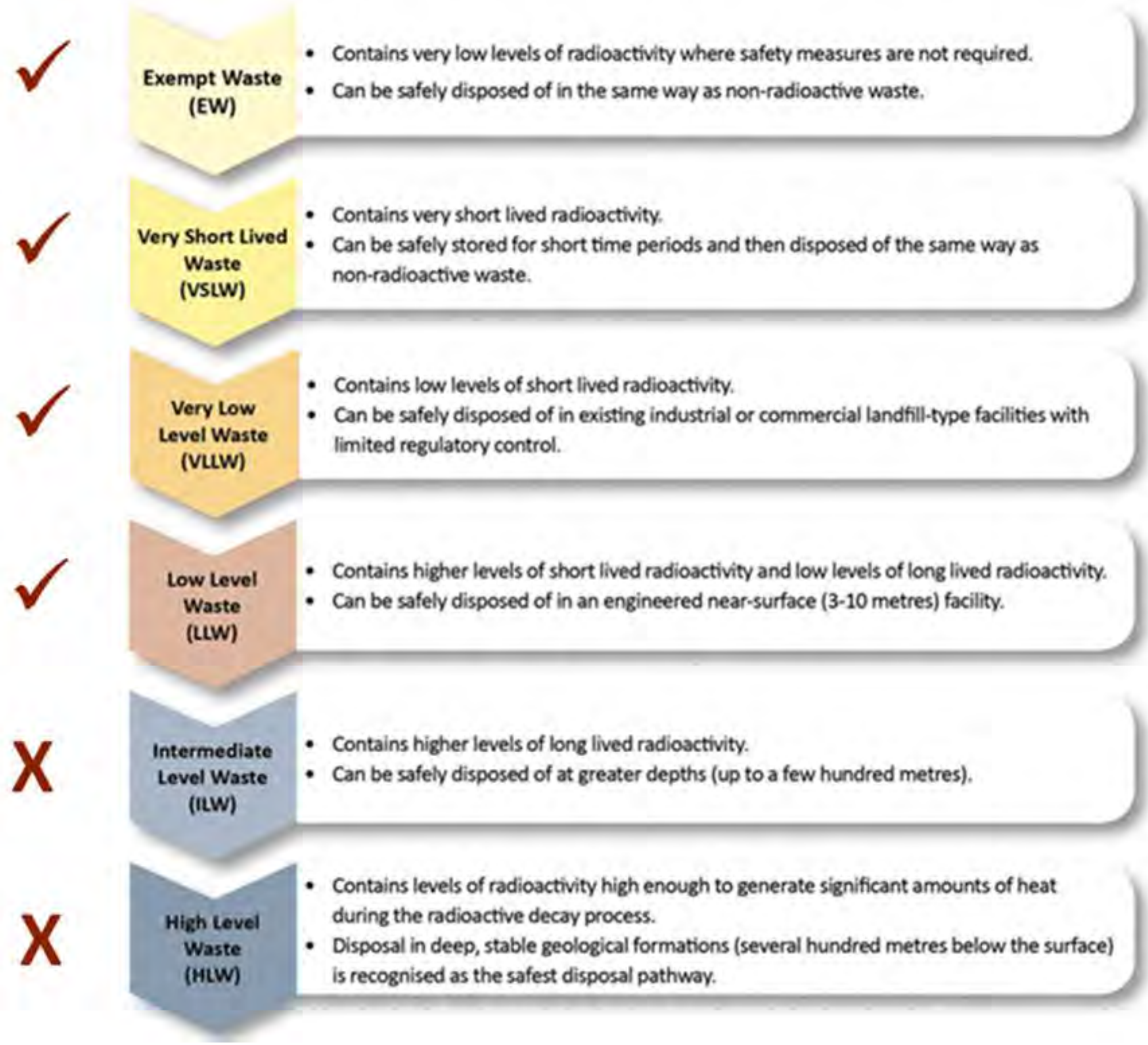


Figure 5-12 Radioactive waste classification and acceptance

Non-nuclear low level radioactive waste

Acceptance criteria for radioactive waste that is being developed for the Facility is described in the WAC (refer to Appendix A.24). The radionuclide concentration limits are set taking into account the actual siting, design and planning of the Facility (e.g. natural geological barrier, arid climate, remoteness, engineered multi layered shielding and barriers, duration of institutional control, site specific management plans and operating procedures) and exposure dose constraints to ensure no person is exposed above the dose limit (as defined in Schedule I of the Radiation Safety (General) Regulations 1983).

Likely radioactive wastes to be disposed of in the cells within specific shafts include radioactive wastes that are generally generated by; medical research and industry, operation of research facilities (e.g. laboratory coats, overshoes, gloves) (see Table 5-4). The proponent would apply for a Licence (Controlled Action) to also accept non-nuclear LLW such as those listed in Table 5-5.

Table 5-5 Examples of the industry and material containing LLW

LLW location	Examples of the industry and materials devices used by humans containing LLW (non-nuclear low level radioactive waste)
Households and industry	• Smoke detectors.
Medical research and industry	• Medical isotopes generated from disease research, diagnosis and treatment (cancer, blood disorders, etc.). • Medical radiography (medical X-Ray), used by dentists and doctors for organ, muscle or bone scans for research, diagnosis and treatment. • Radioisotopes are also widely used in scientific research, e.g. tracing the flow of contaminants in biological systems, determining metabolic processes. • Waste from hospitals, research and university laboratories, also includes waste related to maintenance (clothes, tools, gloves, filters, etc.).
Industry	• Industrial radiography (industrial X-Ray), check the integrity of welds e.g. test aeroplane jet engine turbines for structural integrity) • Sealed industrial gauges (density, moisture and other types of measurement gauges), used to measure levels of liquid inside containers, or to measure the thickness of materials.
Examples	• Americium 241 soil moisture / density gauges, smoke detectors. • Caesium 137 industrial gauges (slurry density, bin level). • Cobalt 60 radiation sterilisation (medical consumables, food etc.). • Iridium 192 industrial radiography, radiotherapy. • Manganese 54 environmental and industrial tracer studies. • Phosphorus 32 biological research. • Strontium 90 thickness gauges (paper & plastic sheet production). • Technetium 99m nuclear medicine diagnostic tests (organ scans).
Rate of use	• According to Australian Nuclear Science and Technology Organisation (ANSTO), on average, one in every two Australians can expect at some stage in his or her life to undergo a nuclear medicine procedure that uses a radioisotope for diagnostic or therapeutic purposes.

Sealed sources

Drawing upon international experience, sealed sources need to meet the <3,700 Becquerel per gram and < 30 years half–life criteria. When a source has a half-life longer than 30 years it can be accepted for disposal if the average value of mass activity of long lived emitters in the waste package is less than 370 Bq/g at the end of the Institutional Control Period (refer to Table 5-5 for examples).

It should be noted that these waste concentration limits can be revised to be applicable to a specific site or design of a disposal facility, if a strong case can be developed. In revising any criteria for a specific site, the safety performance assessment should use data or parameters based upon the local conditions at that particular site. The preliminary safety assessments conducted with RESRAD Modelling indicate that NORM acceptance criteria up to a factor 100 higher than those given in the NHMRC (1992) will still achieve the dose constrain levels.

Table 5-6 summarises the Waste Acceptance Criteria (WAC) proposed for the disposal of sealed sources. The activity of the radionuclides present in the radioactive waste packages would be limited in such a way that the radiological impact of the site is within the dose constraint limits under foreseeable circumstances.

Table 5-6 Generic concentration limits for sealed sources LLW for 100 year Institutional Control Period

LLW	Concentration limit (Bq/kg)	Concentration limit (Bq)[15]
	100 years	100 years ICP
Tritium	1.00E+11	2.00E+13
Carbon-14	5.00E+08	1.00E+11
Radium-226	5.00E+06	1.00E+09
Alpha (α) emitting radionuclides (Am-241, U-238, PU-239)	1.00E+08	2.00E+10
Beta (Β) /gamma (γ)emitters with half-lives > 5y	1.00E+09	2.00E+11
Beta (Β) /gamma (γ)emitters with half-lives ≤ 5y	no limit	no limit

Sources at activity concentration levels above those specified in Table 5-7 would not be accepted for permanent isolation without re-assessing the safety case and seeking approval from the relevant regulatory bodies.

15 4 *Assumes a bulk density of 1 kg/L. The concentration of a radionuclide in the waste package as presented for disposal is calculated by averaging the activity of the source over the weight of the whole conditioned package. For example, the activity of sealed sources, which have been conditioned by being embedded in a solid matrix, can be averaged over the weight of the solid waste matrix. However, to reduce the risks from any future inadvertent intrusion, only one sealed source should be incorporated in a single conditioned package. An industrial gauge source in its approved housing would most likely meet the requirements for disposal if embedded in concrete. In practice, a limit on the maximum activity per package for beta/gamma emitting radionuclides with half-lives of 5 years or less, including cobalt-60, would be imposed by occupational and transport considerations. ARPANSA (2010) Technical Report No. 152).*

Table 5-7 Limits for common sources based on NHMRC near surface code (1992)

Radioisotope	Symbol	Half-life	Decay	Concentration limit (Bq)*
				100 years ICP
Americium-241	Am-	432.17 y	α	2.00E+10
Barium-133	Ba-133	10.74 years	E	no limit
Caesium-137	Cs-	30.07 years	γ	2.00E+11
Californium-252	Cf-252	2.6 years	α	2.00E+10
Carbon-14	C-14	5 715 years	β	2.00E+11
Chlorine-36	Cl-36	301,000	β	2.00E+11
Chromium-51	Cr-51	2.7 days	E	no limit
Cobalt 57	Co-57	271.8 days	E	no limit
Cobalt-60	Co-60	5.27 years	γ	no limit
Gold-198	Au-198	2.7 days	β	no limit
Hydrogen-3 (tritium)	H-3	12.32 years	β	2.00E+11
Indium-111	In-111	2.80 days	E	no limit
Iodine-129	I-129	15.7 million years	β	2.00E+10
Iridium-192	Ir-192	73.8 days	γ	2.00E+10
Krypton-85	Kr-85	10.5 years	β	2.00E+11
Iron-55	Fe-55	2.74years	E	no limit
Lead-210	Pb-210	22.6 years	β	2.00E+11
Manganese-54	Mn-54	312.1 days	E	no limit
Molybdenum-99	Mo-99	66 hours	β	no limit
Nickel-63	Ni-63	96 Years	β	2.00E+11
Polonium-210	Po-210	138 days	α	2.00E+10
Radium-226	Ra-226	1,600 years	α	1.00E+09
Selenium-75	Se-75	120 days	γ	no limit
Sodium-22	Na-22	2.6 years	γ	no limit
Strontium-90	Sr-90	28.8 years	β	2.00E+11
Technetium-99m	Tc-99m	6.01 days	γ	no limit
Thallium-204	Tl-204	3.78 years	β	no limit
Thulium-170	Tm-170	129 days	β	no limit
Ytterbium-169	Yb-169	32 days	E	no limit
Zinc-65	Zn-65	243.87 days	E	no limit

*(alpha (α), Beta (β), Gamma (γ) or Electro capturing (EC))

5.5.3 Waste packaging

Typical waste packaging comprises multiple packaging layers that would be utilised during the product lifecycle that include some or all of the following steps:

- Transport, storage, recovery and permanent isolation.
- Typically, a minimum of two containment layers and often three e.g. plastic lined steel drums on a pallet, strapped together, wrapped or hazardous waste rated (double layered) one tonne bulker bags.
- Pallets placed in sealed 20 or 40-foot shipping containers.

The waste will be transported in containers that are suitable for that type of waste. Examples of the types of containers used in packaging and transport are illustrated in Figure 5-13.

Figure 5-13 Acceptable transport containers

The original IWDF *Waste Acceptance Guidelines* 2011 provide clear criteria for the packaging of waste for delivery to the Mount Walton East site, which is presented below. The proponent has considered the IWDF packaging requirements to be consistent with industry best practices; therefore, waste packaging delivered to the proposed Facility must fulfil the following criteria:

- Not have a total measured weight of more than the Safe Working Load.
- Be capable of being disposed of with the waste.
- Be filled so as to contain no significant voids.
- Be free of ruptures at the point of delivery.
- Be free of external contamination at the point of delivery.
- Not significantly deteriorate during the duration of storage, transport and handling when in contact with the waste.
- Remain intact during normal transport and handling procedures.
- Be strong enough to be walked on if required.
- Be clearly labelled with the waste owner’s name and identification number and material description/name on opposite sides of the waste package.
- Allow no leakage during normal transport and handling operations.
- Be capable of containing all the waste whatever the orientation of the package.

5.5.4 Waste storage

Overview

Storing similar materials together would achieve safe storage and also creates opportunities for the future long-term, storage, treatment and potential recovery of valuable materials or the permanent isolation of waste, as illustrated in Plate 5-2. For planning purposes, the proponent is assuming the development would start at <50,000 tpa in year 1, average 66,000 tpa over 25 years, but would have licenced capacity of 100,000 tonnes per annum of Class IV and V hazardous and intractable wastes. This is to accommodate one-off, campaign -style emergency service infrastructure requirements during a man-made or natural disaster, when significant volumes of materials need to be rapidly removed from communities, or to allow one-off campaign-style transfer of significant mine dumps or tailing ponds containing waste resources from a large industrial customer.Typically, waste received during steady state operations would be temporarily stored on the surface before being placed in a cell for storage (retrievable) or permanent isolation (disposal).

To support future recovery or re-use opportunities for certain waste types, e.g. aluminium spent pot line waste, the proponent is planning a future technology park. This area would focus on research and development and provide space for other research institutions to complete research institutions and development on aspects of the Proposal.

Plate 5-2 Process from creating the kaolin mine and filling a cell with waste materials and creating recovery opportunities

Pre–delivery assessment

A key element of the Proposal is to ensure that wastes are carefully vetted for suitability before the holder is advised that waste can be despatched to the Facility. This approach ensures that:

- Only materials that can be safety handled are delivered.
- The waste customer is aware of the appropriate packaging and transport standards that need to be met for acceptance of the waste.
- Staff are prepared for all waste deliveries and can immediately assess delivered waste to ensure that it is suitable.

The assessment process commences when a waste owner makes contact with a request to send waste to Sandy Ridge. The waste owner would be requested to complete a pro forma (see Appendix A.16) which would provide details on:

- Origin of waste (indicate name of waste-producing facility).
- Identify/describe intractable or hazardous waste constituents.
- Classification and coding under the NEPM.
- Volume and weight of package(s).
- Description and quantification of waste form (solid, sludge, liquid or gas) and applicable material safety data sheets (if available).
- A comprehensive chemical analysis of representative samples performed by a National Association of Testing Authorities certified laboratory.
- Description of previous treatment/conditioning.
- Radiation dose rate on the surface of any packaging.
- Presence of alpha emitters if any.
- Concentration of radioactivity as Becquerels per kilogram (Bq/kg) or Becquerels per cubic metre (Bq/m^3) and/or total radioactivity.
- Description of package and container.
- Any specific additional information advice, especially procedures and warnings related to accidental damage to the container.
- Transport mode and request for transport contractor approval.
- Requested date for delivery (if approved by the proponent).

The information provided would be reviewed against the proponent's outline WAC contained within (Appendix A.24). If the waste meets the WAC, a Dispatch Confirmation Notice would be issued to the waste owner to agree that the waste can be transferred to Sandy Ridge.

Along with the Dispatch Confirmation Notice, notification of the expected packaging and transport standards that the waste owner must comply with would be issued and whether or not the proposed transport contractor is approved by the proponent. These standards would be in line with best practice which is currently defined in the following documents:

- Packaging of waste for transport to the Facility must be in accordance with the *Australian Code for the Transport of Dangerous Goods by Road and Rail* (Australian Dangerous Goods Code; Commonwealth of Australia, 2016, edition 7.4) for all dangerous goods, with the exception of radioactive material.
- All radioactive materials must be transported in accordance with the *Code for the Safe Transport of Radioactive Material* (ARPANSA, 2014b) and the Radiation Safety (Transport of Radioactive Substances) Regulations 2002 (WA) or applicable legislation in each state/territory through which the waste is transported.
- Transport arrangements would conform to the Environmental Protection (Controlled Waste) Regulations 2004 and equivalent legislation in other states and territories and the NEPM (NEPC, 1998a).

The customer's pro forma and the Dispatch Confirmation Notice would be logged in an Electronic Tracking System (TETS). A flow diagram of the conceptual initial contact phase is presented in Figure 5-14.

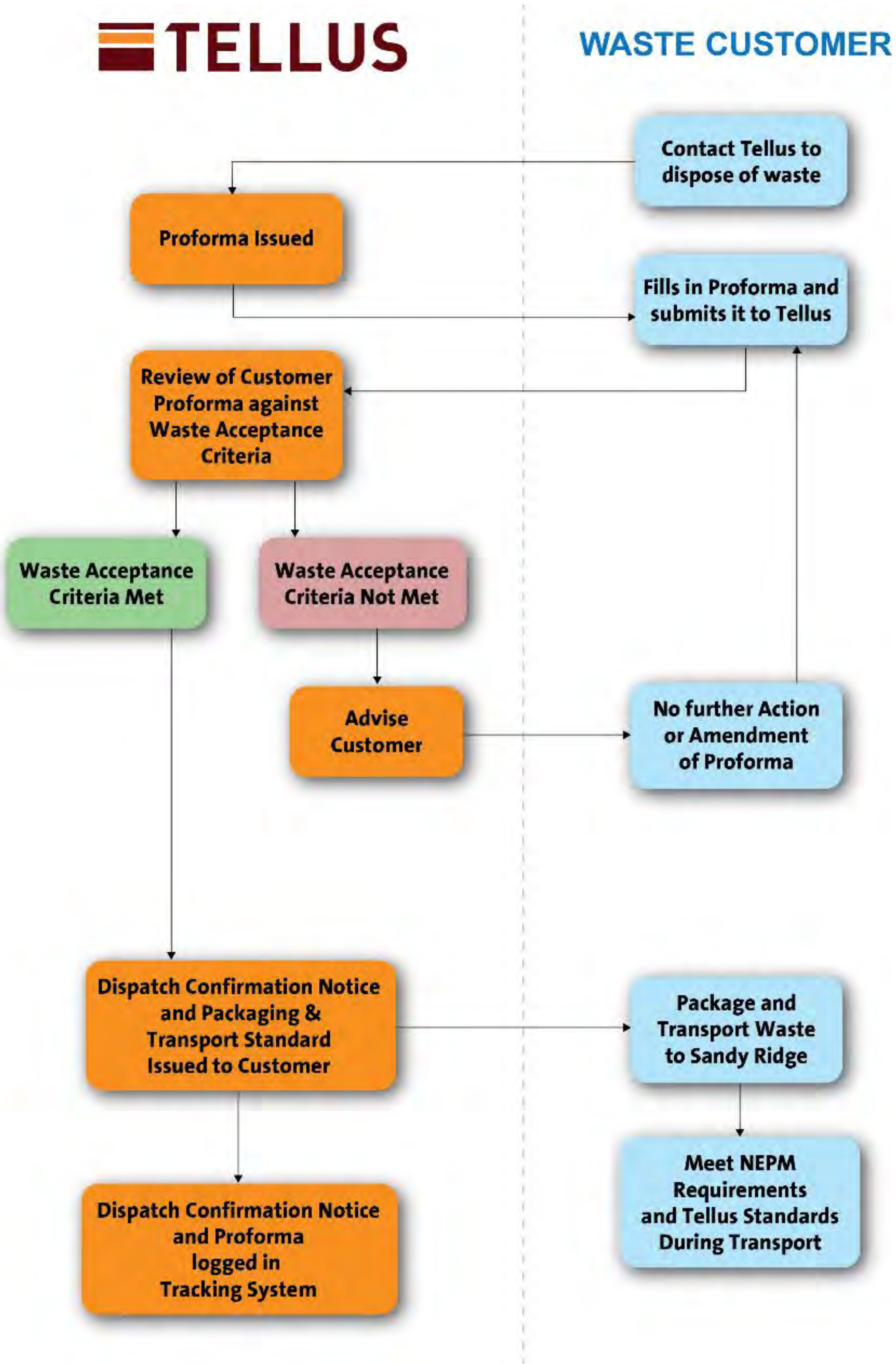


Figure 5-14 Conceptual initial contact phase

Procedures for waste acceptance

The procedures for accepting waste deliveries at Sandy Ridge are underpinned by the following key documents attached to Appendix A.24:

- Waste Acceptance Policy.
- Waste Acceptance Criteria (WAC).
- Waste Acceptance Procedure (WAP).
- Waste Zoning Guide (WZG).

The overall process is shown in Figure 5-15 and described in more detail below.

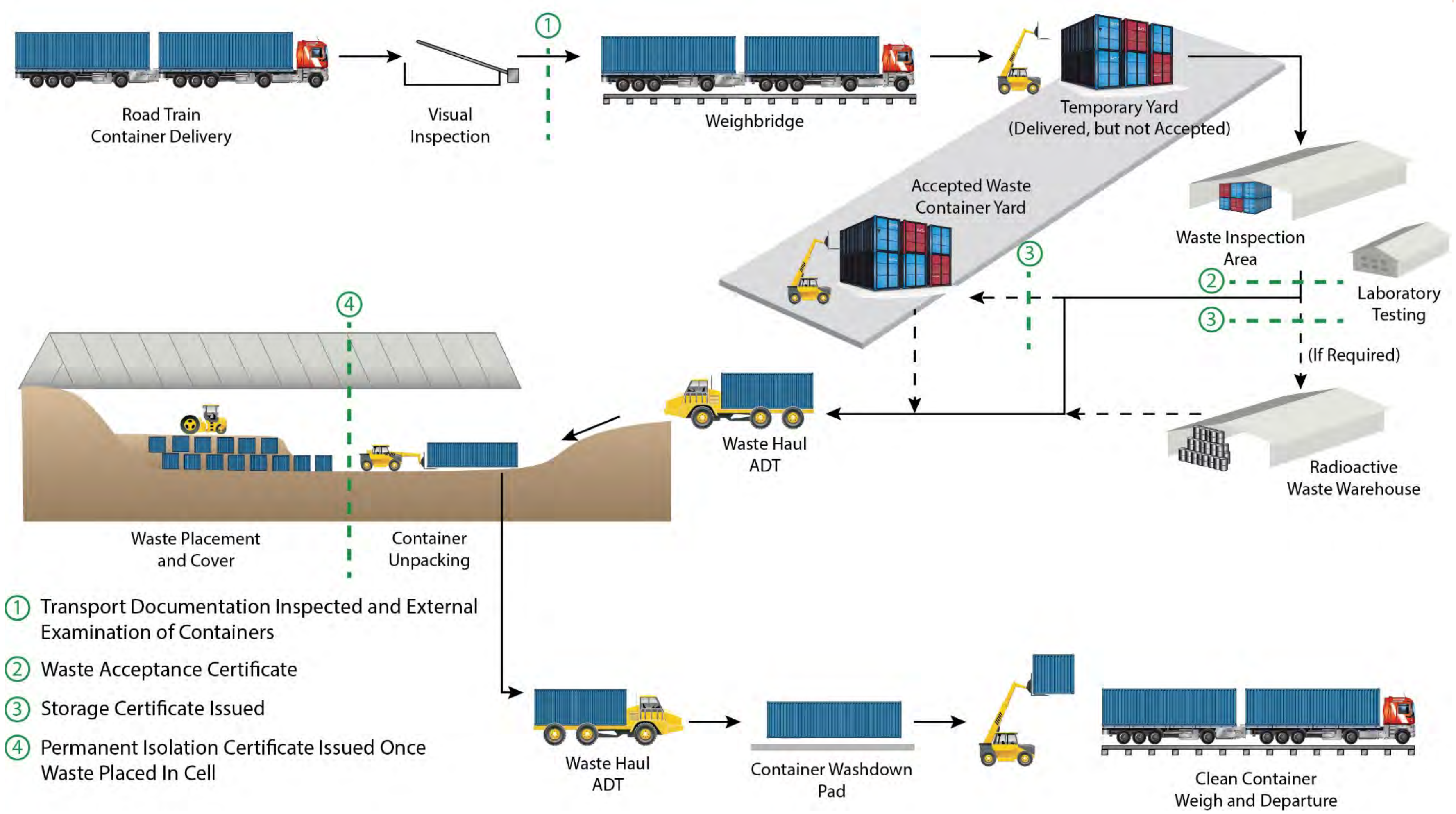


Figure 5-15 Waste materials process flow diagram

Waste Acceptance Policy

The proponent's WAC established for the proposed Facility, is to determine waste types which can and cannot be accepted to achieve safe operation and environmental protection in the longer term at our facilities. The facility has been designed and is in a dry, 70 million year old, thick, stable host geological environment (clay bed) which can store and dispose of the majority of the NEPM 75 hazardous and intractable wastes types subject to them meeting strict WAC. These criteria have been developed following internationally recognised best practice and set out waste characteristics which would and would NOT be suitable for storage or disposal in a geological repository.

The table below describes the hazardous and intractable wastes accepted on site (surface) and below ground in waste cells.

Table 5-8 Hazardous wastes accepted on site (surface) and below ground in waste cells

Hazardous and Intractable Wastes (NEPM 75)	Accepted on site (surface storage)[2]	Accepted below ground in waste cells[2]
Hazardous and intractable wastes (NEPM 75) subject to meeting the characteristics criteria below (examples of acceptable wastes on next slides)	✓	✓
• Liquid and sludges	✓	×[1]
• Explosive wastes	✓	×[1]
• Flammable liquids or solids	✓	×[1]
• Self-combusting wastes or wastes that can generate a gas-air mixture which is toxic or explosive	✓	×[1]
• Highly corrosive or oxidizing	✓	×
• Gases	×	×
• **Clinical waste** *such as infectious hospital waste and body parts*	×	×
• **Municipal Solid waste** *such as putrescible household and commercial waste*	×	×
• Putrescible wastes *which rot such as household rubbish*	×	×
• Uncertified waste *which can not be identified or has not undergone characterisation testing*	×	×
• Reacts with the repository geology *such as dissolving it or producing a gas*	×	×

[1]*Normally excluded unless modified before disposal or during disposal so the operational or post closure safety of the waste cell and facility is not compromised*

[2] ✓ = accepted, × = not accepted. ×[1]= normally excluded but possibly suitable[3]

[3] Classification of Radioactive Waste – ARPANSA RPS20

Example of waste types and volumes that could potentially be accepted

Table 5-9 describes the top 10 main wastes using the simpler NEPM 15 descriptions and the more detailed NEPM 75 descriptions that are likely to be accepted at Sandy Ridge. For planning purposes, the proponent, is assuming the top 10 waste type could account for approximately 90 % of the waste volume.

Table 5-9 Top 10 (<90%) of waste types likely to be accepted at the proposed Sandy Ridge Facility

NEPM 15	Description	NEPM 75	Description
N	Soil / sludge	N205	Residues from industrial waste treatment/disposal operations
N	Soil / sludge	N120	Soils with controlled waste
N	Soil / sludge	N150	Fly ash, excl. coal fired Power Stations
N	Soil / sludge	N220	Soils with asbestos
J	Oils	J120	Waste oil and hydrocarbons mixtures
D	Inorganic chemicals	D220	Lead compounds
C	Alkalis	C100	Basic solutions or bases in solid form
D	Inorganic chemicals	D110	Inorganic fluorine compounds excluding calcium fluoride (SPL)
D	Inorganic chemicals	D120	Mercury compounds
D	Inorganic chemicals	D230	Zinc compounds

[2] *Classification of Radioactive Waste – ARPANSA RPS20*

The figure below describes the potential volume and type of waste by NEPM 75 code that may be accepted at Sandy Ridge. The top 10 main wastes that the proponent is using for planning purposes, account for the majority of the waste volume.

Figure 5-16 also illustrates that for planning purposes, the facility is mostly a chemical hazardous waste facility (99%), but is also applying to accept NORM up to LLR and LLR (1% volume).

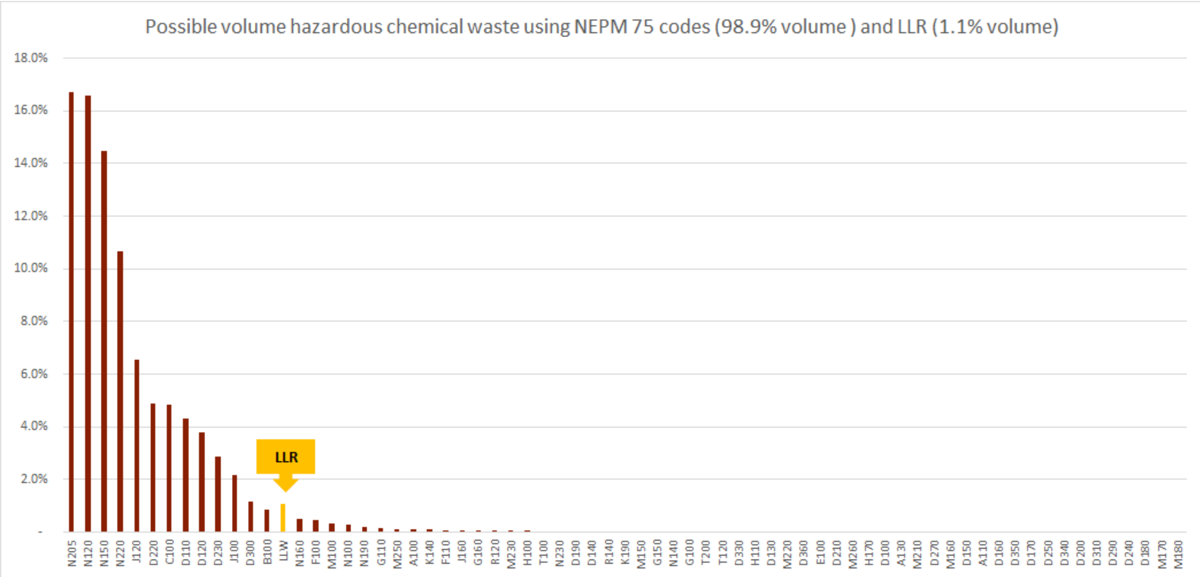


Figure 5-16-Potential volume and type of waste by NEPM code that may be accepted at Sandy Ridge

The aim of the Waste Acceptance Policy is to set a policy framework for the proposed Sandy Ridge Facility. The Waste Acceptance Policy is the Tier One document within the proponent's waste acceptance hierarchy.

This document is intended initially for use by regulators responsible for assessing the facility and issuing licences for the operation of the proposed Facility, and for the formation of procedures to control the process by which waste producers and the proponent's staff would determine if the waste streams may be suitable for storage or permanent isolation.

The document would also be of interest to other stakeholders who wish to understand the approach being followed by the proponent's for waste acceptance, including the safe storage and permanent isolation of wastes.

Waste Acceptance Criteria

The objective of the Sandy Ridge WAC is to establish and explain to regulators, customers and other stakeholders:

- The criteria that would be applied for the exclusion of certain types of wastes.
- The criteria that would be applied to the acceptance of certain types of wastes.
- The requirement for suitable packaging and the criteria that would be applied for packaging acceptance.

Waste Acceptance Procedure

Having established the overarching waste exclusion criteria to be applied at the proposed Facility via the WAC, a gated WAP, using specified test methods and criteria values would be applied to determine if a waste can be accepted.

In addition to considering the specific characteristics of the waste, consideration is also given to how the wastes would perform in the conditions of storage and permanent isolation. This assessment would be performed by a suitably qualified person who has the necessary skill in determining such matters.

Wastes would need to pass through each waste acceptance "criteria gate" to be accepted for in cell storage or permanent isolation.

Waste Acceptance Procedure – Step 1 front gate and weighbridge

On entering the site, trucks would be weighed on a weighbridge and their waste documentation/Dispatch Confirmation Notice would be reviewed by personnel. The exterior of the truck and containers would be inspected at this point. In the event of LLW deliveries, external surface levels of radioactivity would be measured.

If the documentation is not present or is incomplete, the proponent would be unable to confirm that its packaging and transport standards have been met, and the truck would either be turned away from the Facility or directed to the hardstand ('temporary yard' on Figure 5-15) while any uncertainties or discrepancies are resolved. If the documentation meets packaging and transport standards the truck would proceed to the hardstand and/or Waste Inspection Area.

Waste Acceptance Procedure – Step 2 hardstand and waste inspection area

Trucks would drive from the weighbridge to a hardstand ('temporary yard' in Figure 5-15) where the waste would be considered delivered, but not accepted. Shipping containers would be removed from the truck and externally inspected in accordance with operational procedures, and may remain unopened on the hardstand for a period of time to suit the current activities at the site.

The truck would pick up empty shipping containers and can leave the Facility after being inspected for cleanliness and weighed.

From the hard-stand the following steps would occur:

1. The shipping container would be moved across to the Waste Inspection Area, where the container would dock with the side of the building and one end would be opened into the building.
2. An internal inspection inside the shipping container would be conducted to check for damaged/leaking waste packages (this may require removal of some packages) and a selection of waste packages would be removed and taken to the Waste Inspection Area for sampling. The waste package would be audited against the customer's pro forma to confirm the volume and type of waste delivered is as described in the customer's documentation. The outcome of the review of documentation would be:
    a. If the documentation is incomplete or does not match the waste that has arrived, the package would be held pending liaison with the waste customer.

   b. If documentation is complete, the waste packages would be inspected for damage and leaks. If the packaging is damaged significantly the pallet would be held whilst a solution is agreed to with the waste customer. Any damaged or leaking waste package would be made safe as soon as possible to minimise worker or environment exposure to the waste. The waste package would be 'made safe' in accordance with the methodology outlined in the Operating Strategy (Appendix A.16).

3. The samples would be tested (as described in the Operating Strategy) and confirmed that waste matches documentation.
4. The removed waste packages would be repacked and the shipping container closed, and transferred back to the hardstand ('accepted waste container yard' in Figure 5-15).
5. The shipping container remains on the hardstand until it is scheduled to be moved into the waste cell.

Each container would be tracked and logged in the TETS through each handling stage so that its location is known and can be communicated to the regulator or customer if requested.

For bulk materials, the load would be inspected and sampled in the truck before being unloaded into a bulk storage building, vessel, tank, hopper, covered bunker or hardstand area. The frequency of inspection and sampling of waste packages would be adjusted over time as confidence increases in the consistency and reliability of deliveries from any particular customer.

Waste Acceptance Procedure – Step 3 compliance testing

When waste has been deemed acceptable on the basis of a basic characterisation it shall subsequently be subject to compliance testing to determine if it complies with the results of the basic characterisation and the relevant acceptance criteria as laid down in the WAC.

The function of compliance testing is to periodically check regularly arising waste streams are compliant with the WAC. The check has to show that the waste meets the limits of acceptance for the identified critical parameters.

Waste Acceptance Procedure – Step 4 onsite verification

Each load of waste delivered to Sandy Ridge shall be visually inspected before and after unloading, and the required documentation shall be checked. The waste may be accepted at the Facility, if it is the same as that which has been subjected to basic characterisation and compliance testing. If this is not the case, the waste must not be accepted. Upon delivery, samples would be taken periodically. The samples taken would be kept after acceptance of the waste for a period that would be determined by the proponent.

A gated WAP using specified test methods and criteria values would be applied to determine if a waste can be accepted. Detailed explanations of each gate, its associated criteria and an applicable test method(s) required to be used to confirm acceptance, are presented in the WAP (Appendix A.24).

Waste zoning guide

To prevent dangerous interaction, dangerous goods should be kept apart (segregated) from all other goods with which they are not compatible. Segregation can be achieved by storing and handling incompatible goods in separate areas or by the use of physical barriers or distances within the same area.

Systems and procedures would be developed and enforced, and personnel involved in the storage and handling of dangerous goods would be trained and supervised to ensure segregation is maintained at all times. Therefore, arrangements need to be made for the safe storage of these wastes.

Useful guidance for segregating incompatible dangerous goods is provided in *Australian/New Zealand Standard AS/NZS 3833 The Storage and Handling of Mixed Classes of Dangerous Goods in Packages and Intermediate Bulk Containers* which is referenced in the code of practice[16] which, in turn, supports the National Standard. The proponent would adopt the segregation protocols presented in AS/NZS 3833 for all waste materials that are stored on site prior to in cell permanent isolation.

Further information on chemical and LLW zoning is attached in the WZG in Appendix A.24.

Waste treatment or conditioning

Some wastes delivered to the Facility may require treatment or conditioning in order to meet the WAC (Appendix A.24) for placement into a cell. In general, the proponent is not aiming to become a waste treatment contractor or service provider. However, there are presently gaps in the service offerings of the established waste management service companies and some waste treatment processes are best applied immediately prior to placement in the cell.

All waste treatment processes which would be carried out at the Facility have not yet been identified. The proponent currently has test work commissioned with European specialists in the area of non-solid waste solidification and stabilisation. The aim of this work is to confirm the performance of various cement blends with a range of liquid and paste waste types, which would guide the design of the blending and mixing plant. The likely processes that may be implemented at the Facility are described below. A Works Approval would be obtained under Part V of the EP Act prior to the construction of pre-treatment plants. The proponent would ensure that the pre-treatment processes do not result in unacceptable emissions or discharges to the environment.

- **Oily sludge -** Hydrocarbon sludge containing NORM and/or heavy metals cannot always be recovered or safely disposed of using existing treatment processes such as biodegradation, oxidisation, stabilisation or incineration. The proponent is currently investigating methodologies for the stabilisation and solidification of such sludges using pozzolanic materials and cement based additives.

[16] *Page 29 The National Code of Practice for the Storage and Handling of Workplace Dangerous Goods NOHSC:2017(2001)*

Oily sludges would be delivered in either intermediate bulk containers inside sea containers, or as bulk liquids in a tanker truck, with the former being more likely. Oily sludges would be stored until such time as they are ready to be placed in the cell. The oily sludge would then be mixed with controlled measures of binding and stabilising materials such as high carbon fly ash and Portland cement, to produce a cement-like slurry which would either be placed directly into the waste cell, or poured into moulds where it would set. The direct placement slurry would be allowed to set in-place in the cell, and moulded blocks would be placed into the cell in the same manner as other packaged wastes.

- **Non–oily liquid and sludge -** Other wastes in either liquid or sludge form would ideally be reduced in volume, filtered or dried before delivery to Sandy Ridge, preferably by an existing waste management contractor. In the event of some liquid wastes not being able to be treated or only being partially treated (to a sludge), solidification and stabilisation treatment would be provided for these wastes using absorbent materials such as clays and pozzolanic materials such as fly ash and cement. Solidification and stabilisation would typically take place with both materials being added to a mixing device.

  In the event of drums of waste being delivered where a liquid has separated in transport from a paste, absorbent material would need to be added into the drum or container to absorb the released liquid before the waste can be placed in a cell**.**

- **Radioactive waste (sealed sources)** - Sealed sources would be received at site and stored in the Radioactive Waste Warehouse, in the form which they were transported. Prior to placement in a shaft, the sealed source would undergo the proponent's identification and quality assurance and quality control processes before being placed in a concrete filled steel drum.

- **Radioactive waste (NORM and other) -** Material containing NORM may require conditioning or treatment to achieve a physical form suitable for placement in a cell (refer to 'Oily sludge' and 'Non-oily liquid and sludge' above).

  NORM or radioisotope contaminated solid materials may require any voids to be filled with kaolinitic material or cement grout either prior to placement or once in the cell. Examples of such materials could include piping, process machinery, demolition rubble and personal protective equipment (PPE)**.**

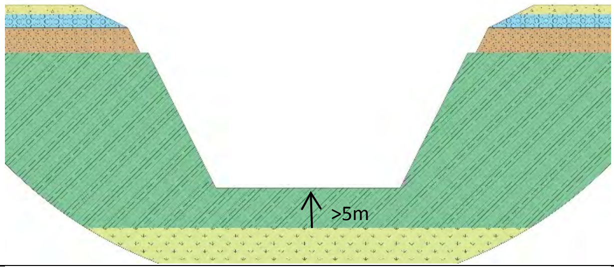
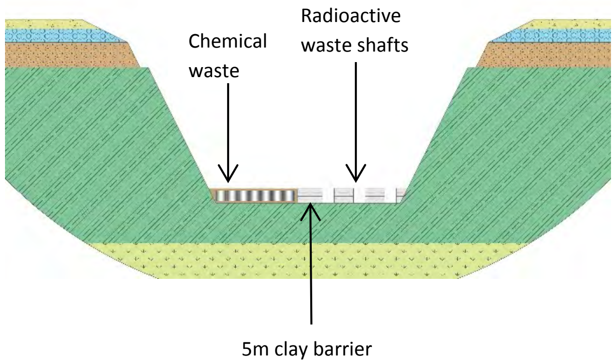
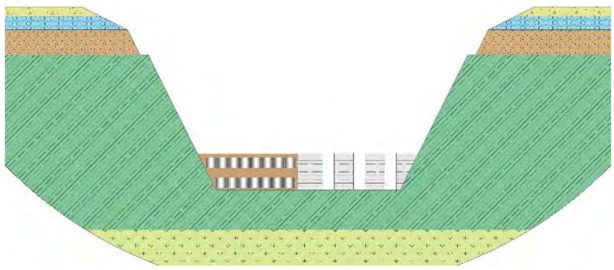
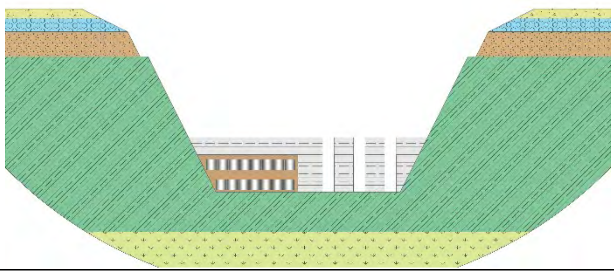
Waste placement

Waste packages would be contained within the kaolin mine void. The base and walls of the void would comprise kaolin clays which are naturally impermeable to water. The natural kaolin would effectively act as a liner as this material is present in a significant thickness and is more impermeable in the long-term than a synthetic liner (e.g. high-density polyethylene [HDPE], geomembrane or concrete), which would break down and disintegrate over geological time (i.e. 10,000 years).

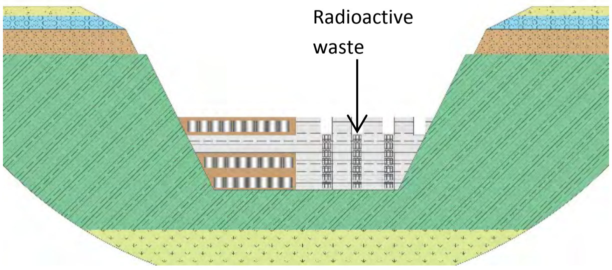
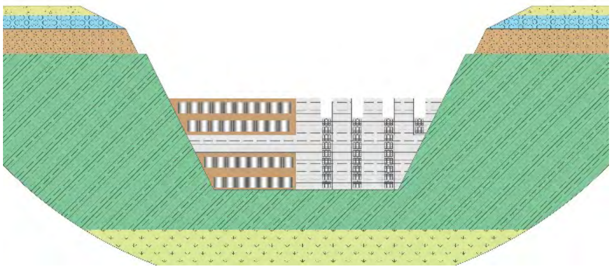
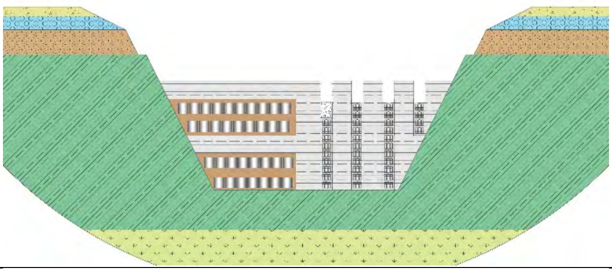
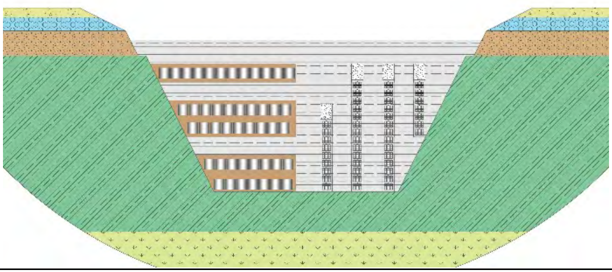
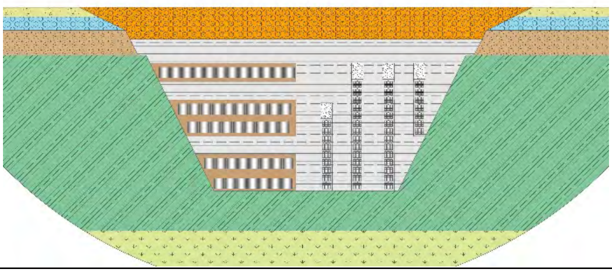
The waste cells would be filled in layers with multiple sections in each layer containing wastes of similar characteristics. All space between waste packages would be backfilled and compacted to minimise air or void space. If this approach is not taken it may result in settlement. Each layer would be compacted, until approximately 7 m below the ground surface, where a thick capping layer of low permeability clay (referred to as a 'seal') would be installed to prevent water ingress into the cell. Following this, more compacted backfill and a clay domed cap would be situated on the top of the cell, to shed any landing rainfall.

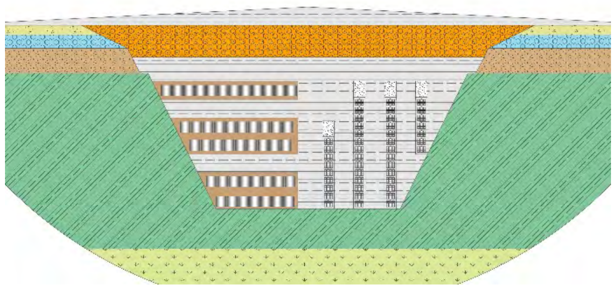
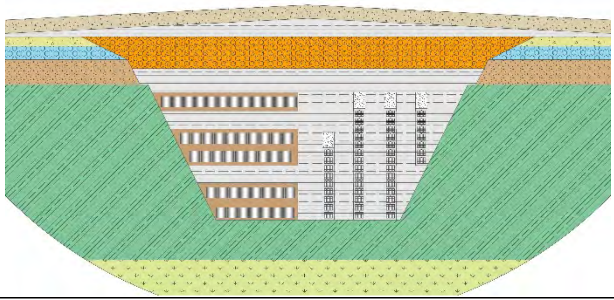
Figure 5-16 illustrates how co-disposed chemical and radioactive wastes would be contained within the cells. The conceptual design of the cells has been independently reviewed by Eden Nuclear and Environment of the United Kingdom (Appendix A.21). The review concluded "that the design of the Facility is excellent and that the proposed multibarrier system offers very good prospects of excellent long-term performance that would be comparable or in excess of that for many other LLW isolation facilities in other countries. This is facilitated by the favourable hydrological and hydrogeological environment". Recommendations were made for further investigations with respect to the outline safety case and activity concentrations of LLW. These recommendations would be addressed during detailed design of the Facility.

The encapsulation of wastes within each cell is subject to rigorous engineering design and compaction testing to ensure the properties of the constructed cell is a close analogue of the existing geological and hydrogeological conditions at the site, which naturally excludes water from the kaolinitic soils located beneath the silcrete layer. A feature survey of the cell would be conducted to confirm the cell is constructed in accordance with the engineering design.

The bottom of the mine void would be a minimum of 5 m above the unweathered/fresh granite bedrock.	
A base layer of waste is placed on one side of 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 would be carried out in accordance with *AS1289.5.8.1*[17] 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 will 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.	

[17] *Australian Standard for testing soils for engineering.*

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.	
A thin (300 mm minimum) layer of compacted granular material is placed over the chemical waste layer. Compaction testing would 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.	

The 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 would have a 1:20 gradient and be an approximate thickness of 2 m in the middle, thinning as it slopes to integrate into the landscape. Subsidence monitoring of the cap would commence.	
Subsoil and topsoil is replaced on the cap after the cessation of subsidence monitoring.	

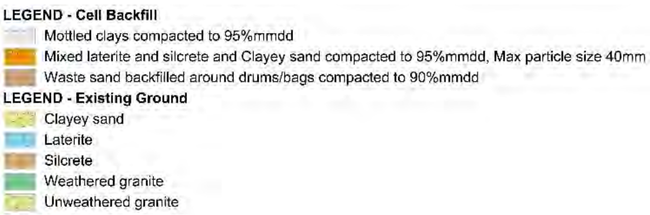


Figure 5-17 Cell containment of chemical and radioactive wastes

The protection of water quality has been considered throughout the cell design, which specifically incorporates the following features to avoid water entering the cell (and therefore leaching contaminants from the waste packages) and to prevent the accumulation of moisture in the unlikely event that small quantities enter the cell from generating leachate from the waste packages.

- No liquids would be placed in the cell.
- A roof canopy over the cell prevents rainfall directly into the cell while it is open.
- The roof canopy is guttered to collect and dispose of collected rainwater.
- Operational bunding around each cell prevents the entry of surface water flow while the cell is open (such flows only occur in extreme rainfall events).
- The absence of a highly impermeable HDPE or concrete seal allows natural and gradual venting of any minor quantities of gases (should they be produced) without pressure damage to a man-made liner or cap system.

- Wastes are stored below ground level (and well below silcrete level) which reduces the likelihood of erosion ever exposing waste.
- The natural topsoil/subsurface soil, thick clay domed cap and the compacted clay layer at approximately 4-7 m depth minimises water ingress and erosion. Based on modelling results, net recharge to the topsoil/subsoil is 1.4 mm per year. Vertical flow below the cap is 0.8 mm per year, into the compacted silcrete and laterite backfill to the compacted kaolinised granite seal/layer. Below this layer the rate of water movement is 0.008 mm per year. These vertical fluxes are extremely low, illustrating that water ingress into the cell is negligible.

Cell planning and inventory assessment – storage of like with like

Shipping containers would be stored on the hardstand until that waste type is ready to be placed in the cell in accordance with the cell scheduler. Bulk materials would also be stored until required in the cell.

The cell scheduler is an electronic planning and inventory assessment tool to effectively manage space within the cell and to ensure the entire batch of a certain type of waste (e.g. arsenic), can be placed in a designated location within the cell that is ready to receive the waste. The cell scheduler would be integrated with the TETS so that each waste package is tracked and its location and depth within the cell logged with a survey coordinate.

The TETS would track each waste package from the point where it is accepted on-site until it is placed in the cell. An example of the Cell Scheduler and tracking system integration is shown in Table 5-9 while Figure 5-15 illustrates how different waste types could be physically separated within the waste cell.

Table 5-10 Example of cell scheduler for tracking of waste from sorting to placement and storage of 'like with like'

Scheduled date for placement	Scheduled time for placement	Shipping container No	Package ID (number from tracking system)	Contents	Cell for storage/isolation	Layer and Section in Cell	Actual date of placement	Actual time for placement	RFID/barcode	Surveyor	Survey coordinates of boundaries of stored waste (MGA94)	Elevation (mAHD) of waste	Date of isolation
10 Oct 2017	9 am	1	D2009-001-001	Arsenic trioxide	2017 – Cell 2	Layer 2 – Section M	10 Oct 2017	9.20 am	D2009-001-001	DH	220,001 6638000	472	10 Jan 2018
	9 am	1	D2006-003-002	Arsenic trioxide	2017 – Cell 2	Layer 2 – Section M	10 Oct 2017	9.30 am	D2006-003-002	DH	220,001 6638000	472	10 Jan 2018
	9 am	1	D4009-129-003	Cyanide	2017 – Cell 2	Layer 2 – Section M	10 Oct 2017	9.40 am	D4009-129-003	DH	220,001 6638000	472	10 Jan 2018
21 Oct 2018	10.30 am	2	X3456-222-001	Solidified pesticides	2018 – Cell 1	Layer 3 – Section G	21 Oct 2018	10.30 am	X3456-222-001	AS	220,001 6,639,000	480	21 Nov 2018
	10.30 am	2	F4567-204-002	Solidified pesticides	2018 – Cell 1	Layer 3 – Section G	21 Oct 2018	10.45 am	F4567-204-002	AS	220,001 6,639,000	480	21 Nov 2018
	10.30 am	2	G3450-765-003	Solidified pesticides	2018 – Cell 1	Layer 3 – Section G	21 Oct 2018	10.55 am	G3450-765-003	AS	220,001 6,639,000	480	21 Nov 2018
	10.30 am	2	H4367-765-004	Solidified pesticides	2008 – Cell 1	Layer 3 – Section G	21 Oct 2018	11.30 am	H4367-765-004	AS	220,001 6,639,000	480	21 Nov 2018

Figure 5-18 Placement of wastes within the waste cell and a roof canopy covers the cell

When the cell scheduler indicates that a particular container is scheduled for placement, it would be loaded onto a waste haul articulated dump truck (ADT) and driven into the cell. The shipping container would be removed from the waste haul ADT and placed on the floor of the cell adjacent to the designated disposal and isolation area.

The shipping container would be opened and the pallets of waste packages removed in accordance with the Outline Operating Strategy (Appendix A.16).

There are situations where an entire sea-container would be placed in a cell. In this case, holes are cut into the roof, grout or concrete is poured in place (to remove airspace) and the filled container is then buried with its contained waste.

Bulk material in a form suitable for placement would be transported from the surface storage area to the cell by an ADT when required and placed directly into a cell.

Prior to unpacking shipping containers into the cell, the roof canopy would be in place. The roof runs on rails and would cover the full length of an active waste cell. The purpose of the roof canopy is to exclude water from the cell until it is capped, to avoid the generation of leachate within the cell and avoid any potential structural impacts that may affect the integrity of the cell walls. There are some waste types which may be placed in a cell without a roof as the materials being placed are not immediately leachable, such as some contaminated soils and contaminated railway sleepers. Any such cell construction would be designed with a drainage sump to enable pumping-out of any direct precipitation whilst the cell is open.

VLLW and LLW would be managed separately from other wastes and would have a dedicated shaft constructed within the cell. Handling of VLLW and LLW would be in accordance with the Radioactive Waste Management Plan (Appendix A.14). Equipment and larger objects may be filled with kaolinitic material or cement grout/concrete either prior to placement in the cell, or in situ. In general, (though dependent upon activity and isotope presence), NORM would not be placed in shafts; rather, they would be placed in a designated area of the cell. Shaft placement would normally be reserved for higher activity LLW.

Survey coordinates of each placed waste package or area of bulk waste placement would be recorded. Each section of the cell would be surveyed and depths of stored waste updated in the TETS. Once the waste customer's shipping container or bulk materials have been placed in the cell, a Placement Certificate would be issued to the waste customer.

Backfilling of cell

Chemical waste

Once the base layer of waste packages is in place, granular material would be backfilled to completely fill any voids between the waste packages. This would be done to minimise the risk of subsidence or settlement of the covering material, creating a solid structure with no voids. Additional granular backfill would be placed on top of the completed layer of waste packages, sufficient to allow the safe movement of vehicles without damage to the waste packages below. Additional layers of waste would be stored then backfilled and compacted in the same manner (refer to Figure 5-19). Compaction testing would be carried out in accordance with *AS 1289.5.8.1–2007 Methods of testing soils for engineering purposes – Soil Compaction and density tests – Determination of field density and field moisture content of a soil using a nuclear surface moisture density gauge – Direct transmission mode.*

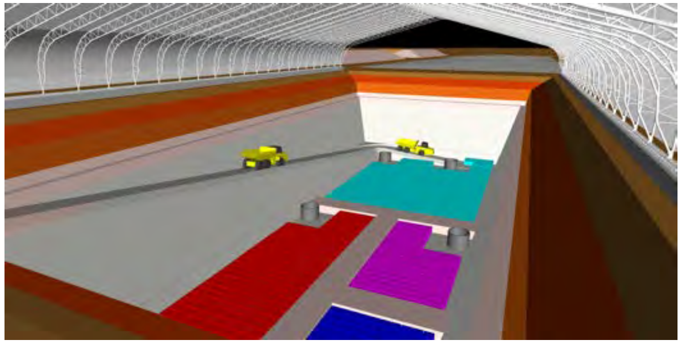
Following the placement of the final waste layer, capping layers are used to fill the remaining void and cover the completed waste cell. This would occur at approximately 7 metres below the ground surface. These serve to provide a barrier:

- Between the waste materials and the surface.
- To prevent water infiltration.
- To prevent erosion.

When available, waste kaolin from the kaolin refining circuit would be used as the seal (first capping layer). This material has a compacted permeability of approximately 3.0 x 10^{-8} m/s (Douglas Partners, 2015) and would be 3 m thick. In the event waste refined kaolin is unavailable, overburden and low grade kaolinised granite would be used for this layer. Compacted kaolinised granite material has a permeability of approximately 6.0 x 10^{-8} m/s (Douglas Partners, 2015) and would be 3 m thick.

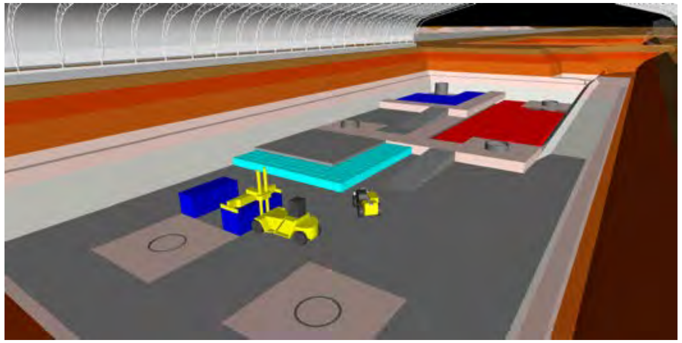
The remaining thickness of backfill up to the surrounding natural ground level is filled with compacted crushed silcrete and laterite material, with some kaolinised granite or clayey sand material used if additional volume is required. This layer would be typically 4 m thick (refer to Figure 5-19). The roof canopy is moved to the next cell after the second complete lift (600 mm) of the capping layer is placed over the waste. Prior to removing the roof an internal temporary sump would be created in a portion of the cell and on top of the first 300 mm cap so that any stormwater can be contained and pumped from the cell.

Figure 5-19 Backfill stages



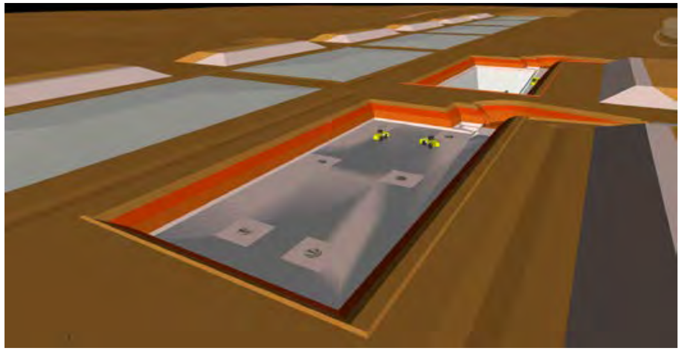
Base layer of waste cell

Waste packages would be segregated, so those with similar characteristics are stored together as illustrated by the different colours. Each section of waste packages would be separated horizontally and vertically by compacted, highly impermeable kaolinitic material.



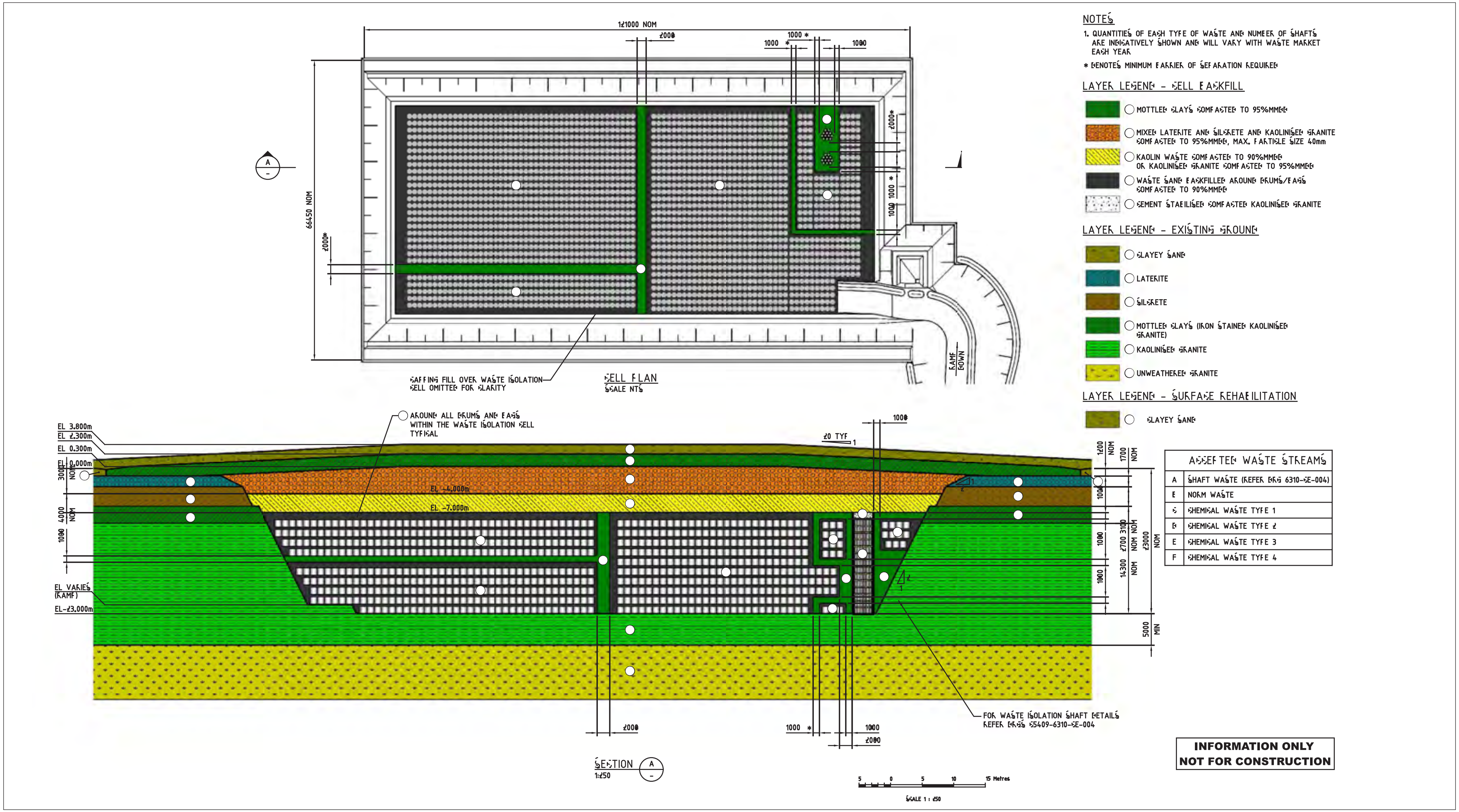
Layers of waste

Additional layers of waste would be stored then backfilled and compacted in the same manner as the base layer. Each layer of waste packages is separated vertically by compacted, granular material. Different waste types are separated both horizontally and vertically by compacted kaolinitic material. The number of waste layers in a cell depends on the waste package form and the depth to the base of the kaolinised granite material.



Capping layers

Following the placement of the final waste layer, capping layers are used to fill the remaining void and cover the completed waste cell. An approximately 3 m thick layer of low permeability waste kaolin or kaolinised granite material (seal) would be placed in multiple lifts on the waste layer. This would be topped with another 4 m thick layer of silcrete and laterite material. The cell is now ready for its clay dome. The overall conceptual cell profile is shown in Figure 5-17.



ACCEPTED WASTE STREAMS

A	SHAFT WASTE (REFER DWG 6310-CE-004)
B	NORM WASTE
C	CHEMICAL WASTE TYPE 1
D	CHEMICAL WASTE TYPE 2
E	CHEMICAL WASTE TYPE 3
F	CHEMICAL WASTE TYPE 4

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CAD Ref: g2294_PER_05_15.dgn
Date: Nov 2016 | Rev: B | A4

Aurora environmental

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Sandy Ridge Facility

Conceptual cell profile

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Figure:

5-20

LLW shaft packing

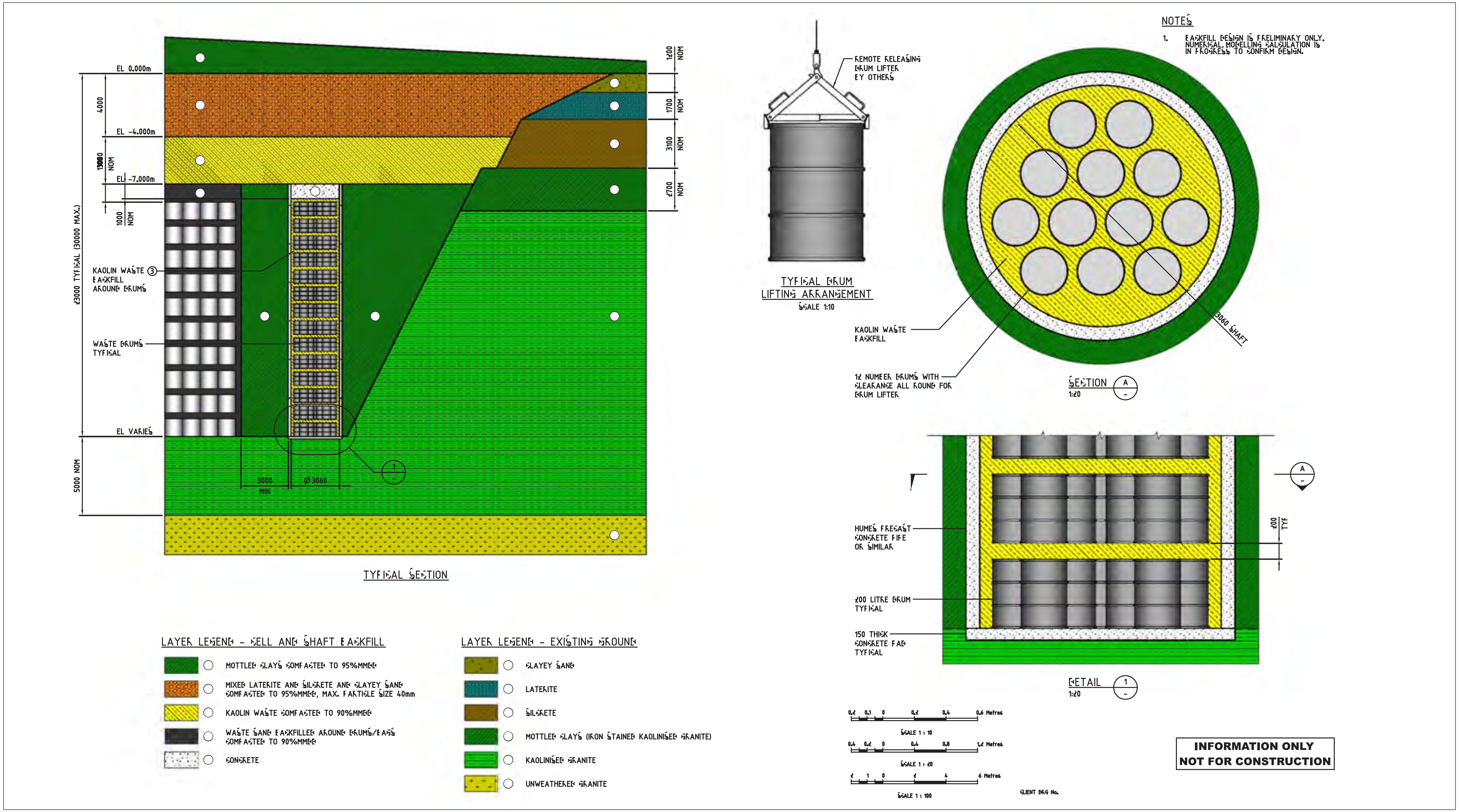
It is preferable that LLW of higher activity are not combined with chemical waste storage; therefore, vertical shafts would be constructed within the cell from prefabricated concrete or steel liners surrounded by natural materials to provide shielding (refer to Figure 5-21).

Figure 5-21 Radioactive waste storage (shaft in cell)

A number of shafts would be constructed within a cell using pre-formed cylindrical shaft segments. As the cell is progressively filled in waste layers to approximately 7 m below the ground surface, more pre-formed segments are stacked upon each other to create a shaft. A buffer of compacted kaolinised granite is placed around each segment to provide further isolation from chemical waste at the same level (refer to Figure 5-22).

Radioactive waste can be placed into the shaft at any time, but it is expected that the placement of chemical waste and pre-fabricated shaft segments surrounding the shafts would progress to several metres of depth before radioactive waste placement occurs, so as to provide vertical physical separation between the radioactive waste and workers on the active surface.

Radioactive waste packages would be lowered into the shaft and then backfilled with kaolinitic material to fill void spaces. Higher activity wastes may be backfilled with concrete slurry. A substantial pre-fabricated lid would be emplaced as a temporary cap on top of placed radioactive waste in the shaft to prevent un-authorised access or incidental exposure. When the shaft is filled with waste to the base of cap level (approximately 7 m below ground level), and permanent lid would be put in place and the structure covered by the cell cap materials as described previously.



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Sandy Ridge Facility

Conceptual design of low level radioactive waste isolation cell

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Figure:

5-22

Non-shaft stored LLW

NORM at sufficiently low radioactivity may be placed in the same manner as chemical wastes in the open area of the waste cell. Whenever possible, the cell layout would have all shaft storage of radioactive materials at one end of the cell, with the adjacent space used for NORM, and chemical wastes in the rest of the cell.

Cell dome capping

The final capping layer is formed of compacted kaolin which has a low permeability (permeability approximately 6.0 x 10^{-8} m/s [Douglas Partners, 2015]) and placed in the form of a shallow dome, so as to shed stormwater from the structure into perimeter V drains, which flow to a sump.

The domed cap would be monitored for subsidence for a period of 10 years in accordance with the WFDCP (Appendix A.17). Following the monitoring period, topsoil would be respread and seeded. Vegetation monitoring would be conducted for 10 years.

5.6 Outline safety case

The Sandy Ridge outline safety case is both a written presentation and an operational requirement dealing with the technical, management and operational information regarding the hazards and risks of operation and how they are managed and mitigated. It considers the transport, construction, operation and closure of the Facility drawing on best practice examples from around the world which are internationally recognised as suitable to host a geological repository.

The proposed Facility would only accept wastes if they meet strict waste acceptance criteria and would store compatible 'like with like' wastes to ensure operational safety and create opportunities for the future recovery and reuse of valuable materials.

The outline safety case (Appendix A.15) is underpinned by the dry arid desert environment and the multi-barrier system, which provides long term containment and isolation.

5.6.1 Environmental suitability for an arid near surface geological repository

The environmental suitability of the Facility is presented in Table 5-11.

Table 5-11 Evidence supporting the proponents near surface geological repository over the lifecycle of the facility

Characteristic	Sandy Ridge – ClayVault
Type	• Near surface geological repository.
Can the hazardous waste be safely isolated from the biosphere for the long term?	• Waste can be safely isolated over the long term (hundreds of thousands to millions of years).
Recycling opportunities and contribution to the Circular Economy	• Hazardous waste should be seen as a valuable resource. • 'Like with like' waste materials would be stored together securely and safely until a way is found for the waste to re-enter the circular economy. The next generation may have a better recovery technology toolbox and can recover the materials in an economically viable way. • Permanent isolation of waste material if no further use is identified.
Does the site require ongoing monitoring after closure?	• No, the system is 'passively safe'. However, an appropriate insurance and assurance package would be in place over the 100 year closure and monitoring period to verify this. • Clay beds do not corrode or decay. • Clay beds have a self-healing characteristics (clay plasticity).
Liability	• There is no ongoing potential liability as there is a permanent isolation of the waste in the geological barrier.
Geology and stability (seismic, tectonic, volcanic activity)	In the proposed development envelope: • Kaolin clay bed is approximately 260 million years' old. • Geological stable thick, flat, extensive kaolin clay bed. • The rate of movement and the location is within a seismically quiet portion of a stable shield and is very unlikely to cause any significant tectonic activity (uplift, subsidence, or fracturing) in any timeframe relevant to the Proposal. • There has not been any igneous activity in the region for over 1,000 million years. There is no reason to expect that there would be any sub-surface or surface volcanic activity within this part of the stable craton for at least 50 million years. • It is in an area with the lowest hazard rating for earthquakes in Australia. This means there is a very low risk of earthquakes affecting the structural stability of the waste cells.

Characteristic	Sandy Ridge – ClayVault
Safety barrier types (multi barrier safety case)	• Engineered barriers. • Natural geological barrier (extensive kaolin clay bed). • If man-made engineered systems fail, then the 'fail safe' stable extensive geology would isolate the waste from the biosphere. • The multi-barrier safety case is increasingly recognised as a cost effective and preferred method of permanently isolating difficult to manage wastes. • The geological barrier provides isolation of wastes from the environment over the very long term (tens of thousands or millions of years), something a man-made barrier cannot achieve and creates significant additional opportunities for the future recovery and recycling of valuable materials from the waste which can re-enter the circular economy.
Liner dimensions	• Kaolin bed and overlying silcrete layer is the liner and is laterally extensive. • ~ 160 km long. • ~20 km wide and flat. • Clay bed ~7 to 24m thick (average 14 m). • ~ 40 m deep. • No credible risk of water ingress or contamination leaving the site.
Permeability (Perm.) of the geology (indicator regarding the risk of seepage)	• In situ kaolin has very low permeability. • When the thickness and permeability of the clay are combined, there is no credible risk of water ingress or contamination leaving the site (seepage). • The combination of a virtually flat plateau, cemented surface layers, and semi-arid conditions creates the stable geomorphology of the area.
Climate	• Semi-arid – low erosion and water ingress risk.
Groundwater contamination risk?	In the proposed development envelope: • A thick impermeable silcrete layer above clay bed (15 million years ago when climate became arid).

Characteristic	Sandy Ridge – ClayVault
	• The hydrogeological investigation confirmed that there are no regional aquifers present. • Clay bed has been dry for millions of years. • No credible scenario for groundwater contamination. • Not subject to flooding, nor is it predicted to be in the future. • Very low risk of encountering cyclones. • Low rainfall – averages just over 250 mm of rainfall per annum and evaporation is greater than 2,000 mm per annum. This means very little rainfall occurs across the proposed development envelope and generally water would evaporate before it infiltrates the ground surface. • The silcrete layer, which is a hard surface, ensures that even very large rainfall events are contained within the top few metres of the ground. Once rainfall does enter the soil profile, it is quickly evaporated before the water can infiltrate. • There are no defined surface watercourses or water bodies in the proposed development envelope. It is located close to the top of a watershed which means that catchment areas for surface water flows are small.
Other features	• Very low rates of erosion. • Lack of commercial mineral deposits. • It is an area of extremely low population (non-permanent camp approximately 52 km away). • No potential for medium to high value agriculture. • The site has no special environmental features. • No special cultural or historical significance has been identified through a completed heritage study and consultation with stakeholder's familiar with the area. • There is little credible risk to human health or the environment from suitably conditioned and packaged wastes that might be stored and isolated at the Sandy Ridge Facility. • Wastes would be accepted from within WA, from other states and territories, and from Australia's Exclusive Economic Zone.

Provided the storage or isolation cells are capped to prevent any vertical surface water or groundwater infiltration into the cell, the characteristics listed above essentially eliminate the possibility that contaminants contained in waste materials could migrate outside of the cell and affect sensitive environmental receptors.

Even in the highly unlikely event that water did enter a cell, the highly impermeable clays surrounding the cell would prevent migration of contaminants over more than a few metres from the cell walls. As a consequence, virtually any chemically contaminated waste could be accepted at the site (NEPM 75), provided:

- Wastes placed in the cell are dry non-compactable solids which are non-reactive (stabilised).
- They are placed in a manner that ensures that no voids are left.
- The cells are securely capped to prevent the intrusion of surface water.

5.7 Onsite Class II landfill

A putrescible landfill (Class II) would be constructed to service the accommodation camp and offices. Only wastes generated at the Facility would be disposed of in this landfill. Wastes may include; food scraps, plant materials and inert materials (e.g. cardboard, bricks, concrete). The landfill would comprise a series of single trenches (opened as required) that are 60 m long, 3 m wide and 3 m deep.

5.8 Site access and traffic management

Site access roads have been preliminarily designed to suit a maximum of a 36.5 m long road train configuration. An existing unsealed access road would be utilised to access Sandy Ridge and new unsealed access roads would be created. The existing road is the IWDF access road, which is not a gazetted road but is a private road managed by the Department of Finance. Upgrade works required for the IWDF access road include:

- Construction of an intersection with slip-lanes at the IWDF access road and Great Eastern Highway.
- Re-forming and re-surfacing of IWDF access road.

The use of and any alterations to the IWDF access road would require the permission of the Department of Finance (Building Maintenance and Works) whom manages the road on behalf of the State.

The Great Eastern Highway intersection upgrade requires Main Roads WA approval prior to construction works.

New unsealed access roads would connect the upgraded existing IWDF access road alignment to the proposed development envelope, infrastructure area, accommodation camp and the Class II landfill.

5.9 Ancillary infrastructure

5.9.1 Introduction

Infrastructure to support the mining and waste repository operation is summarised below and shown in Figure 5-23.

- Accommodation camp to be located approximately 1.6 km south-east of the infrastructure area, with a capacity to house up to 40 people. Includes camp carpark and access roads.
- Putrescible landfill (Class II) for disposal of camp and office waste.
- Sewage treatment systems (BioMAX® systems or equivalent), would be installed at both the accommodation village and at the infrastructure site.
- Administration and gatehouse building and carpark, including (offices, first aid, training centre, communications, lunch room, and ablutions).
- Potable water treatment facilities (reverse osmosis plant).
- Water tanks including raw saline water, potable water and firefighting water systems.
- Kaolin drying fuel storage facility (most likely LPG).
- Diesel storage tank, piping reticulation and bowser for refuelling of trucks and mobile plant
- Switchboard and generators (see Section 5.9.3 below).
- Access roads, gate and perimeter fence.
- Water supply pump station (at Carina Iron Ore Mine) and pipeline.

5.9.2 Water supply

This section addresses matters in relation to the water source and viability of the source for the Proposal. Specifically, water demand and the agreements in place to secure the water source are discussed. The viability of using the Carina Iron Ore Mine as a water source is also presented.

Water demand and agreements in place to secure the water source

The Facility requires water for the following components of the Proposal; for potable use at the accommodation village and administration building and amenities, for use in the laboratory, for use in kaolin processing, for vehicle washdown and for firefighting. Non-potable water (RO reject and raw saline water) would be used for dust suppression and compacting of waste cell backfill and capping.

The proponent would apply for a Licence to Take Water from the Department of Water following completion of the environmental impact assessment (i.e. Part IV) process. It is anticipated that an agreement would be made with Mineral Resources for access to the Carina Pit water via overlapping tenure following the Part IV environmental impact assessment process. The operations at the Carina

Pit would be nearing their end around the time that construction of Sandy Ridge would commence. It is unlikely that the two operations would conflict, and discussions held with Mineral Resources representatives indicated that the mine cell is proposed to be left as a cell lake at mine closure.

The water within the pit is held within fractured rock and Mineral Resources' licence (GWL 169652) allows for abstraction of 1.6 GL per annum. Significantly less water is proposed to be extracted (estimated at 0.18 GL per annum) than Mineral Resources is currently abstracting.

Viability of using Carina Iron Ore Mine as a water source for 25 years

The Carina Mine currently has an excess of water from dewatering which is disposed of in evaporation ponds. By the time Sandy Ridge is in construction or operations, the Carina Pit would be closed and is planned to be partly backfilled and left to flood naturally. The salinity of the water is close to seawater at approximately 33,000 mg/L Total Dissolved Solids (TDS) which is less saline (in concentration) than other locations assessed by Rockwater (2015). The pH of the Carina Mine water is currently close to neutral.

It is anticipated that a maximum of 495 kL/day or 0.18 GL of water would be required for operations per annum from Carina Pit. Rockwater Pty Ltd (Rockwater) (2015) completed an assessment of suitable water supplies in the vicinity of Sandy Ridge. As there is a distinct lack of water within the proposed development envelope, Rockwater identified the Carina Iron Ore Mine as the best source of water. Mineral Resources' Carina Iron Ore Mine is located approximately 13 km to the south-west of the site on Mining Lease M77/1244–1 (refer to Figure 5-1).

When compared to the 2014 dewatering rate of 2,250 kL/day, is a 78% reduction in volume. At the abstraction rate of 495 kL/day, the water level is likely to reduce from 379 m AHD to 357 m AHD.

The water balance calculated by Rockwater (2015) at the water level contour of 350 mAHD shows that rainfall (332 kL/day) and groundwater inflows (707 kL/day) combined, with evaporative losses (411 kL/day) subtracted, equate to a water surplus of 628 kL/day. If 495 kL/day is abstracted for the Facility, this leaves a residual surplus of 133 kL/day.

Therefore, water would rise, albeit slowly, and the abstraction would be sustainable. There is also water stored at deeper depths, as shown by Polaris Metals/Mineral Resources whom have dewatered to 315 mAHD, suggesting 42 m of water could be available over the 25 year period, if it was needed.

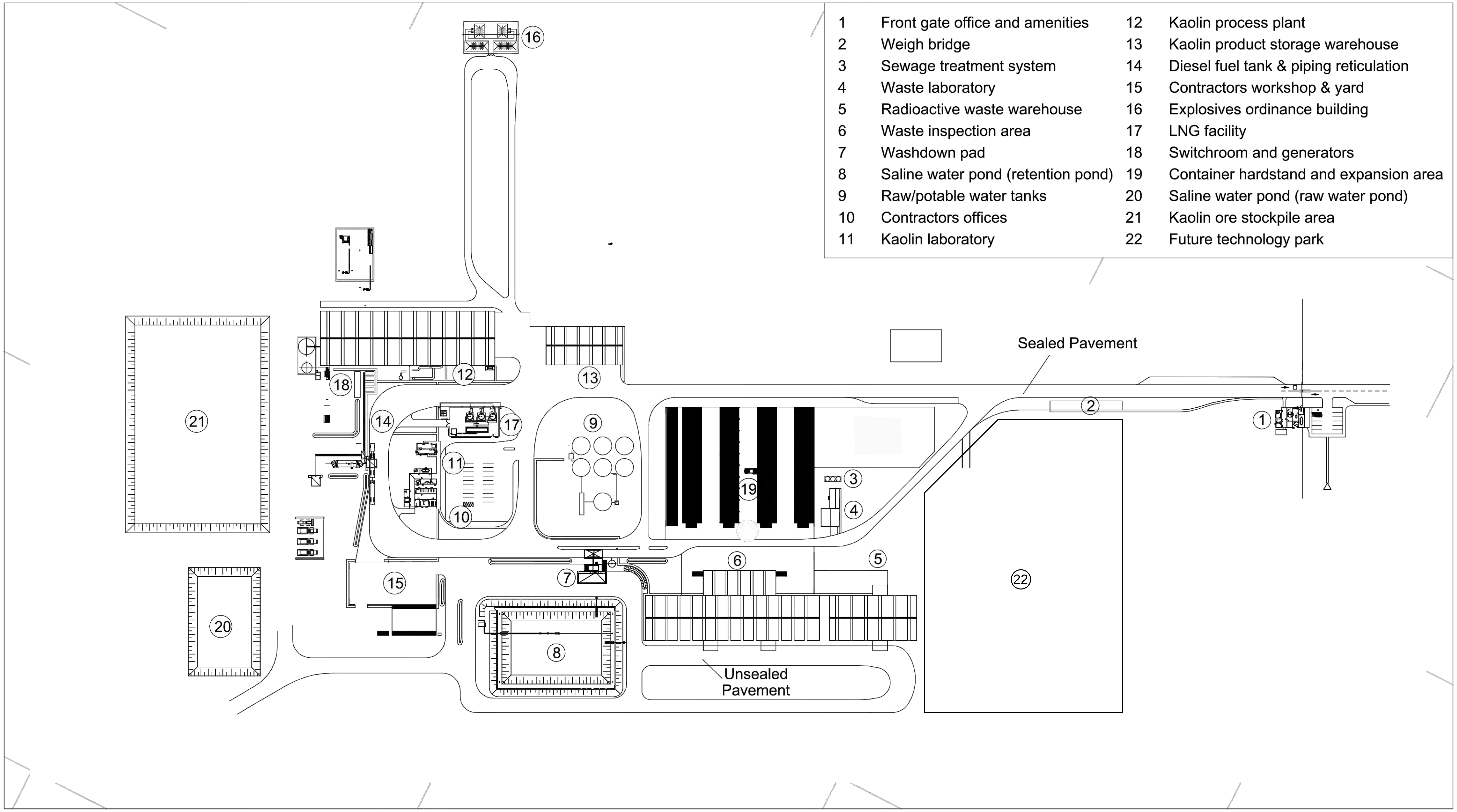
To transport water from the Carina Pit to the water tanks within the proposed development envelope, a floating pump would be placed within the Carina Pit and a pump station (including water tank, pumps, genset and small diesel tank) would be constructed adjacent to a 12 km long dedicated water pipeline (refer to Figure 5-1).

A floating pump, suitable for full time saline water exposure, would pump the raw water from the Carina Pit into the pump station which would pump water into the pipeline and into water storage tanks within the proposed development envelope. Saline water delivered to Sandy Ridge would be treated in a RO plant to produce fresh water for potable use in:

- The accommodation camp.
- Administration building.
- Amenities.
- The laboratory.
- Kaolin processing.
- Vehicle washdown.
- Firefighting.

RO reject and raw saline water are used for dust suppression and compacting of waste cell backfill and capping.

It is anticipated that an agreement would be made with Mineral Resources to enable the grant of tenure to the proponent that would allow access to the Carina Pit water. The proponent would also apply for a Licence to Take Water under the *Rights in Water and Irrigation Act 1914* after the Ministerial Statement and Commonwealth approvals are granted.



1	Front gate office and amenities	12	Kaolin process plant
2	Weigh bridge	13	Kaolin product storage warehouse
3	Sewage treatment system	14	Diesel fuel tank & piping reticulation
4	Waste laboratory	15	Contractors workshop & yard
5	Radioactive waste warehouse	16	Explosives ordinance building
6	Waste inspection area	17	LNG facility
7	Washdown pad	18	Switchroom and generators
8	Saline water pond (retention pond)	19	Container hardstand and expansion area
9	Raw/potable water tanks	20	Saline water pond (raw water pond)
10	Contractors offices	21	Kaolin ore stockpile area
11	Kaolin laboratory	22	Future technology park

Notes:
- Design Supplied by Onyx Projects

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0 60m
Scale 1:3,000
MGA94 (Zone 51)
CAD Ref: g2294_PER_05_04.dgn
Date: Nov 2016 | Rev:G | A4

Author: C. Dorrington | AE Ref: THO2014-003
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Sandy Ridge Facility
Infrastructure area conceptual layout
Public Environmental Review

Figure:
5-23

5.9.3 Energy supply

Power supplies are required for the kaolin processing plant and associated support infrastructure and at the accommodation camp. Infrastructure may be powered by diesel, dual-fuel and/or solar generators located at the site. The anticipated average electrical demand required is 1.5 megawatts.

Fuel supplies are needed to power the generators, kaolin dryers and mobile plant. Gas and diesel storage tanks would be located in the main infrastructure area, with mobile energy suppliers topping up fuel onsite on a regular basis. Diesel day tanks would be located at the camp and the water supply pump station.

5.9.4 Site security

The *Code of Practice for the Security of Radioactive Sources* (ARPANSA, 2007) would be complied with. The code sets out the security requirements to be implemented in order to decrease the likelihood of unauthorised access to or acquisition of radioactive sources by persons with malicious intent.

In the absence of direction from ARPANSA on security screening requirements for staff working with radioactive materials, the Maritime Security Identification Card system would be adopted as a minimum standard.

5.10 Opening hours, workforce and accommodation

The Proposal would normally be open for waste deliveries four days a week, for 52 weeks a year. This would provide waste customers with flexibility in scheduling waste deliveries. Deliveries and waste operations may occur on the remaining three days of the week if required due to:

- Delays due to inclement weather (particularly affecting the access roads).
- Short term peaks in waste supply.
- On-site activity delays e.g., re-positioning of infrastructure (e.g. cell roof) or equipment breakdown.

It is anticipated the proposal would require a construction workforce of up to 90 people and an operational workforce of 25 to 35 people.

During the construction phase employees and contractors would be housed at a temporary accommodation camp onsite until the permanent camp is built. An accommodation camp with a capacity to house up to 40 people would be constructed and would include; kitchen, dining room, wet mess, bedroom modules, laundry modules, recreation and exercise facilities.

During the operations phase, where possible, local people would be employed to run the Facility to provide employment opportunities to the local community. Approximately five people would be based in Perth and Sydney in administrative roles. Working hours would be 12-hour day shifts Monday to Thursday and two people working 12-hour day shifts on Thursday to Monday for maintenance purposes.

5.11 Closure and decommissioning

Closure, rehabilitation and decommissioning would proceed in accordance with the MCP (provided in Appendix A.19) and the WFDCP (provided in Appendix A.17).

The phases of management for closure of the Facility are illustrated in Figure 5-24.

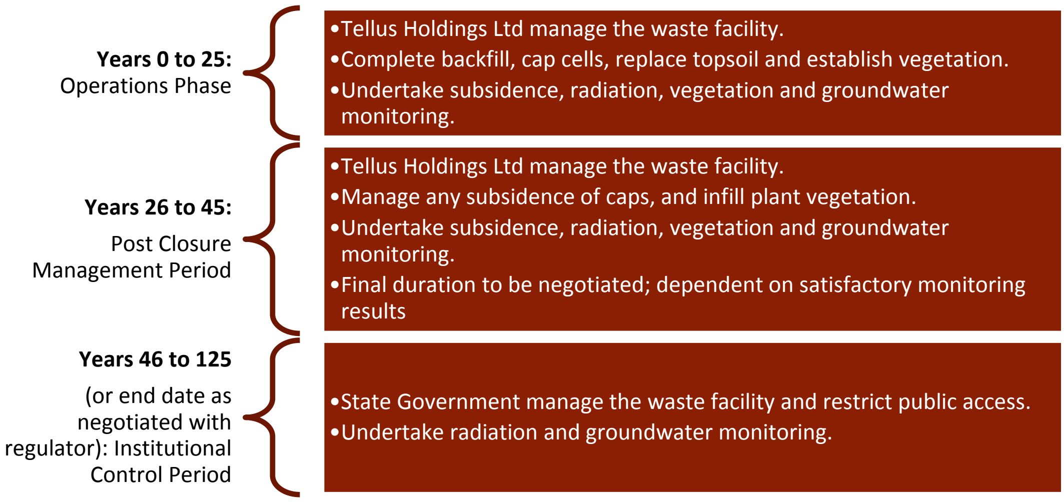

Figure 5-24 Phases of closure

Elements of the Proposal that are covered in the decommissioning and closure phase are listed in Table 5-11.

Table 5-12 Elements of the Proposal and location of information regarding decommissioning and closure

Physical elements	MCP	WFDCP
Class V/Class IV cell closure	×	✓
Front gate office and amenity building	×	✓
Water pipeline	×	✓
Roof canopy	×	✓
Technology and recovery park	×	✓
Radioactive waste warehouse	×	✓
Accommodation camp	✓	×
Class II landfill	✓	×
Internal roads	✓	×
Waste inspection area	✓	×
Container hardstand	✓	×
Weighbridge	✓	×
ROM pad	✓	×
Diesel fuel tank, piping reticulation and bowser	✓	×
Waste laboratory	✓	×
Kaolin laboratory	✓	×
Kaolin processing plant	✓	×
Washdown pad and washdown treatment and storage system	✓	×
Water tanks	✓	×
Contractors offices, laydown yard and maintenance workshop	✓	×
Kaolin products storage warehouse	✓	×
Saline water ponds	✓	×
Explosive ordinance building	✓	×
Sewage treatment systems	✓	×
LNG facility	✓	×
Switch room and generators	✓	×

The regulator of a Class V Waste Facility in WA (currently DER) has no published closure requirements for Class V landfill sites, but based on consultation with DER, closure requirements would centre on the post-closure monitoring and management of potential emissions and discharges. The proponent would also discuss the closure objectives with the ICP Government Manager (see below for more detail).

The objectives of closure are:

1. Structurally stable, non-eroding disposal and isolation 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, the proponent would need to meet the completion criteria and provide evidence to regulators as stipulated.

During mine closure and decommissioning, groundwater and vegetation establishment would be monitored as outlined in Appendix A.19.

The radiation monitoring programs would follow a conventional format for each of the types of hazards described.

The aim of the monitoring program 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 Proposal 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 on 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).

5.12 Environmental monitoring program

The environmental monitoring program is adapted based on on-going interpretation of results and risk assessments before permanent disposal and waste acceptance. The following environmental radiation monitoring program (Table 5-12) would be followed as a minimum to ensure that the operations have no detrimental effect on the environment.

Table 5-13 Environmental 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 six representative locations.	2/year from representative locations.
Radon	Track etch	Radon decay product (RnDP)	1/year from three locations.	2/year for first three 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 area), after disposal and after final capping.
	Boundary gamma surveys	γ-survey	Once off.	Annually.
	Equipment contamination clearance	α, β, γ-survey	Once off.	As required before equipment that might be contaminated leave site.
Waste storage	Radiation store	γ-survey	-	2/year.
	Stockpiles	γ-survey	-	2/year.

5.12.1 Dust monitoring

Samples are deposited upon a pre-weighed (25.5 cm x 20.5 cm) glass-fibre filter paper with an effective sampling area of 382.5 cm^2 (22.5 cm x 17.0 cm). Upon completion of sampling, the filter paper is re-weighed to determine the mass of dust collected. The sub-samples are stored for a period of not less than seven days to allow short lived radioactive products to decay, and are then presented to the α-spectrometer to determine the long-lived α-emitting activity. The mean α-activity from the sub-samples is integrated over the total active area to determine total collected long-lived α-activity.

5.12.2 Environmental area γ- monitoring program

Environmental area γ- monitoring program would consist of:

- Site boundary monitoring surveys.
- γ- monitoring to determine background levels.
- Clearance survey.

The environmental gamma survey would be done at a height of 1 m from the ground. Keeping the monitor and audio indicator in the on position allows for the identification and monitoring of smaller areas with elevated gamma radiation levels. A grid of approximately 15 m x 15 m is recommended.

- All monitoring locations are recorded using a Global Positioning System (GPS) receiver.
- Area γ- monitoring of the site boundary would be undertaken as part of the pre operational and operational baseline program. The monitoring locations would be recorded with the GPS coordinates and compared to the pre-development monitoring results.
- A survey would be undertaken once mining has been completed and before disposal to confirm the background levels in the cell. The survey results with the GPS coordinates would be recorded.
- A clearance survey of each cell would be undertaken after completion of earthworks and capping to confirm area above cell is at background levels. Results and GPS coordinates would be recorded.

5.12.3 Occupational monitoring program

The purpose of the occupational monitoring program is to ensure that radiation exposures of the workforce remain below the statutory annual limit (20 mSv) and as low as reasonable achievable. Occupational radiation monitoring is carried out on a cross section of the employees. Results of area surveys and time and motion studies are also used to estimate potential doses for employees. The personal monitoring to be conducted would include:

- Personal dust samplers and analysis for gross α activity.
- Personal γ- monitoring with personal electronic dosimeters (Canary).

- Work Area γ- monitoring to demarcate areas based on exposure risk.

5.12.4 Personal dust monitoring

Personal dust sampling would be conducted in accordance with *AS 3640:2004 Workplace Atmospheres -Method for Sampling and Gravimetric Determination of Inhalable Dust, 2004.* Samples would be analysed for LLA. The International Commission on Radiolocial Protection (ICRP) recommends that a default Measurement of Aerosol Size Distribution (AMAD) of 5 µm is used for occupational exposures whilst for environmental exposures the default AMAD is taken to be 1 µm (ICRP, 1994).

Sampling sizes for the baseline program would be in accordance with the *Occupational Exposure Sampling Strategy Manual* (National Institute for Occupational Safety, 1977) to ensure that there is 90% confidence that at least one individual from the highest 10% exposure group is contained in the sample.

5.12.5 Personal γ-Radiation monitoring

Personal γ monitoring would be conducted to confirm the individual dose is kept below the action levels. This would be done with personal electronic dosimeters or Thermoluminescent Dosimeter (TLD) badges.

5.12.6 Area γ- Monitoring

Work areas would be classified based on the potential annual radiation exposure in excess of the natural background and would be demarcated accordingly. The average level of natural background gamma radiation would be determined in the pre-operational surveys.

5.13 Institutional control period

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 and permanent isolation 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 ICP for Sandy Ridge is the Radiological Council of WA. As per NHMRC (1992) the Radiological Council of WA may vary the ICP according to the usage of the facility.

5.13.1 International standards for institutional control periods

Other near-surface geological sites around the world have ICP ranging between 100 and 300 years (Nuclear Energy Agency [NEA], 1999). A summary of ICPs applied to similar facilities overseas is provided in Table 5-13.

Table 5-14 Institutional control periods at near surface facilities

Country	Near surface geological facilities	Institutional Control Period
Australia	IWDF Mount Walton East	100 years
Czech Republic	Dukovany, Richard and Bratrstvi Facilities	200–300 years
France	L'Aube and La Manche Facilities	300 years
Hungary	Puspokszilagy Facility	100 years
Japan	Rokkasho No 1 and Rokkasho No 2 Facilities	300 years
South Africa	Vaalputs Facility	300 years
Spain	El Cabril Centralised Waste Disposal Facility	300 years
United Kingdom	National Low Level Waste Repository	100 years

Sources: NEA (1999), Empresa Nacional de Residuos Radiactivos (ENRESA) (2009), LLW Repository Ltd (2011), South African Nuclear Energy Corporation (no date)

5.13.2 Appropriate authority for institutional control

As the proponent is a private company and does not own the land, at an agreed milestone in the ICP, responsibility for the Proposal may be transferred to the WA Government. The site would then be managed by a government agency determined by the WA Government. This agency would then be recognised as the appropriate authority for institutional control. As part of the transfer of responsibility from the proponent to the WA Government, the proponent would 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 length of the ICP.
- The land in question is a Crown land.
- The Government exists in perpetuity, whereas it is feasible or even likely that at some future date, the proponent 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 if and when required.

5.13.3 Financial provision during institutional control period

Financial provisioning information for closure of the Proposal has been provided by the proponent. Closure cost estimates are a part of the overall financial planning of the Proposal, and the final estimates would fall into the Bankable Feasibility Study. The costings provided are based on the size of areas within each domain to be closed (as defined during the pre-feasibility phase of the Proposal) 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 the life of the Proposal (i.e. growth of the quantity) to account for any change to the size of areas to be closed.

The outcome is a total estimated direct cost for each domain and subtotal for elements within each domain. The proponent recognises the importance of updating the financial provisioning cost estimates with each revision of the MCP, to ensure closure is included in the proponent's annual financial budgets.

The proponent would provide appropriate financial assurance for the expected closure costs of the Proposal. The proponent intends on this financial assurance being via appropriate contributions to the WA Mining Rehabilitation Fund, consistent with the DMP's standard policy for mining projects in WA.

The proponent would agree to the final legal structure of the financial assurances to be put in place following detailed legal, tax and accounting advice and following consultation with relevant government agencies. Such a financial assurance package would also be considered on a holistic basis with other financial assurances to be provided for the Proposal (i.e. for an ICP).

6 STAKEHOLDER CONSULTATION AND ENGAGEMENT

6.1 Introduction

The method for community consultation and engagement was developed in accordance with the International Association of Impact Assessment's *Social Impact Assessment: Guidance for Assessment and Managing the Social Impacts of Projects* (2015) and the proponent's internal communication plan for major projects. The main steps in the consultation and stakeholder engagement process were to agree a strategy, identify key stakeholders, implement the strategy and record stakeholder feedback. These steps are explained in more detail below.

6.2 Consultation strategy

During development of the ESD and PER, the proponent prepared its own communication plan which provided a strategy for consultation around major milestones, for example, public review of the draft ESD. During that period, the proponent undertook consultation with the community and relevant government agencies.

The purpose of consultation undertaken to date has been to:

- Identify key community and government stakeholders (refer to Section 6.3).
- Inform the community of the Proposal.
- Involve relevant government agencies in concept design development.
- Advise potentially directly affected stakeholders of the Proposal and its potential environmental benefits and risks.
- Record comments and issues about the proposal and concept design from those who may be affected.
- Seek ideas from interested parties to be considered in finalising the design.
- Advise stakeholders on how they may obtain further information or communicate concerns, complaints or suggestions.

A key issues management system was adopted to capture, collate and analyse feedback for its forward engagement program.

6.3 Key stakeholders

The Proposal has a large geographic and social footprint which presents challenges when identifying key stakeholders. The proponent defined its key stakeholders by assessing its proposed operations and what potential impacts (beneficial or negative) the Proposal may have during pre-development, construction, operation, mine closure and decommissioning. A list of key stakeholders and interested parties was developed in early 2012 and continually revised up until the submission of the PER (refer to Table 6-1).

Table 6-1 Stakeholder list through the development of the Proposal

Stakeholder category	Sector / group
Aboriginal groups	• Native title claimant groups.
Government	• Commonwealth government representatives. • WA Government representatives. • Local government representatives.
Non-government organisations and service providers	• Community groups. • Environmental groups. • Research institutions. • Private sector service providers (including Indigenous businesses).
Industry and business	• Regional and economic development boards. • Local and regional industries and businesses.
General public	• Local. • Regional. • State. • National.

6.4 Cultural heritage community engagement

In 2014 and 2015, the proponent engaged with local Aboriginal families. The aim of consultation was to present the Proposal and understand what potential risks or impacts may exist for Aboriginal heritage.

Consultations and further assessment (refer to Section 10.7.3) deemed the Proposal as being unlikely to have an impact on Aboriginal cultural heritage. The assessment was based on the following due diligence considerations:

- The Proposal is unlikely to harm known Aboriginal objects or places.
- The Aboriginal Heritage Inquiry System search did not indicate moderate to high concentrations of Aboriginal objects or places in the study area.
- The study area does not contain landscape features that indicate the presence of Aboriginal objects.
- The cultural heritage potential of the study area appears to be low.
- There is an absence of sandstone rock outcrops likely to contain Aboriginal art.
- No Native Title claimants are currently registered for the proposed development envelope.

6.5 Community and government engagement

Having achieved a sufficient level of confidence in relation to the technical and commercial business case of the Proposal, the proponent's approach to stakeholder consultation was to develop and implement a stakeholder engagement plan based on the following approach:

- Engage at a 'grass roots' level with the local community most directly affected by the Proposal, and the Government agencies whose approvals were required to start field work.

- Engagement was then broadened to incorporate other key Local, State and Federal government groups and any other interested stakeholders that had been identified either during the initial stakeholder scan or subsequently in discussions with other stakeholders.
- During communications with stakeholders, the proponent explained the Proposal in terms of definition, timelines, potential impacts and benefits and then listened to feedback on concerns, issues or opportunities raised. The proponent responded by modifying the Proposal to address any significant issues that were raised.

The proponent' policy of early engagement, open and transparent discussions, meant that the proponent could adapt both the consultation plan and the Proposal design on the basis of feedback received during the consultation process.

Various phases of stakeholder consultation for the Proposal has been completed. To date, neutral to broad support has been received with the majority of stakeholders requesting to be kept informed as the Proposal progresses through the approval process. Stakeholders to date have included:

- Local Indigenous groups and Traditional Owners.
- Local communities of Coolgardie and Kalgoorlie.
- Local, State and Australian Government departments.
- Local businesses in Coolgardie and Kalgoorlie.

In parallel to stakeholder consultation, the proponent has a policy of creating as many local business opportunities as possible and training and hiring locally. The proponent has already contracted many WA local and Aboriginal-owned businesses. The proponent has also supported a local rangers training program in association with the Goldfields Sea and Land Council, WA Government and local stakeholders.

6.5.1 Government pre-planning focus meeting

In October 2015, the proponent initiated a pre-planning focus meeting that was attended by key decision making authorities within the WA Government. The Commonwealth DoEE was also represented. The aims of the meeting were to (a) introduce and present the Sandy Ridge Proposal to a number of key government departments simultaneously and (b) seek feedback on the environmental and engineering work undertaken by the proponent at that point in time. Refer to Table 6-2 for more information.

6.5.2 Public consultation for the draft ESD

The proponent held two 'community drop-in' days at Coolgardie and Kalgoorlie February 10 to 12, 2016 (refer to Plate 6-1 and Plate 6-2). The aims of the drop-in days were to

a) Present the work carried out by the proponent to date.
b) Present the scopes of work that would be covered in the PER.
c) Seek and record feedback on the concept of the Proposal.

Approximately 40 people attended the drop-in days between Coolgardie and Kalgoorlie.

Plate 6-1 Community consultation in Coolgardie

Consultation tools and methods were designed and targeted to maximise opportunities for feedback from stakeholders. The communication tools included eight A1 posters which contained a range of environmental and engineering information about the Proposal (refer to Plate 6-1). Feedback forms and a questionnaire was also provided. These tools were supported by an email address to allow stakeholders to inquire about the Proposal. The identification of key issues raised during the drop-in days is summarised below. A summary of the feedback received from key stakeholders over the last four years is presented in Table 6-2.

Plate 6-2 Community consultation in Kalgoorlie

Types of waste

The majority of attendees were interested to know what types of waste would be accepted at the site. The proponent confirmed that it would only take chemical wastes and LLW, such as equipment used in the medical and research sectors, and naturally occurring radioactive material. A list of wastes that would and would not be accepted are shown in Figure 6-1.

Transport of wastes

Many residents were interested in likely transport routes for clay and waste materials. Specific issues related to:

- Increased traffic.
- Cumulative impacts at Freemantle Port.

- Spill events along transport routes.

Jobs and training

Participants showed significant interest in potential employment and business opportunities associated with the Proposal. Feedback was generally related to expressions of interest in the service and trade sector with a few expressing interest in providing specialist services, including the Indigenous (tourist) sector.

Feedback on future jobs indicated that the Proposal's working conditions must be family friendly i.e. days/hours for availability to local families for ongoing jobs that are secure to keep local residents and population. The Proposal Must be a win/win situation on all levels e.g. job and the environment.

Flora and fauna

Residents and members of government inquired as to the amount of vegetation that would have to be removed as part of the Proposal. They also inquired as to whether there would be any potential impacts on threatened, rare, listed or endangered species. The proponent responded by saying that baseline surveys undertaken to date indicate the site is not constrained by sensitive plants and animals and further studies would be undertaken before the final PER is lodged for approval. In addition, ongoing ecological monitoring would take place during construction and operation of the Proposal.

Water resources

Many who attended were aware the proposed site is located in an arid environment and lacks a true water source. People were interested in where water would be drawn from and how it would be transported to site. The proponent provided information about proposed water resource infrastructure measures and indicated that further information would be provided within the PER.

SAFETY CASE AND WASTE ACCEPTANCE CRITERIA

INDUSTRY WASTE SOURCE	BEST PRACTICE SAFETY CASE
✓ Resources (mining and oil and gas)	✓ Certified Management System
✓ Manufacturing (heavy industry, chemicals) generation	✓ Strict regulated packaging and transport systems
✓ Utilities (power, water, waste including households)	✓ Strict waste characterisation and acceptance criteria
✓ Agriculture, forestry and fisheries	✓ Multiple man made barriers (“engineered barrier”)
✓ State Emergency Service (man made or natural disasters)	✓ Thick 70 myr old dry clay bed (“geological barrier”)

TYPICAL CONTAINER TYPES

WASTE TYPES	Accepted on site (surface storage)[3]	Accepted below surface in cells[3]
• **Hazardous chemical wastes subject to meeting the characteristics criteria below:**	✓	✓
• **Liquid and sludges**	✓	✗[1]
• **Explosive wastes**	✓	✗[1]
• **Flammable liquids or solids**	✓	✗[1]
• **Self combusting wastes**	✓	✗[1]
• **Highly corrosive or oxidizing**	✓	✗
• **Gases**	✗	✗
• **Clinical waste** *such as infectious hospital waste and body parts*	✗	✗
• **Municipal Solid waste** *such as putrescible household and commercial waste*	✗	✗
• **Uncertified waste** *which can not be identified*	✗	✗
• **Naturally Occurring Radioactive Material (up to LLW[2])** *such as oil & gas industry scale*	✓	✓
• **Low level Waste (LLW)** *smoke detectors, exit signs, industrial gauges & medical isotopes*	✓	✓
• **Intermediate level waste (ILW) High level waste (HLW)** - *reprocessed & spent nuclear fuel*	✗	✗
• **Nuclear waste** - *from power generation and defense use*	✗	✗

1 *Normally excluded unless modified before disposal or during disposal so the operational and post closure safety of the waste cell and facility is not compromised*
2 *Classification of Radioactive Waste – ARPANSA RPS20*
3 ✓ = accepted, ✗ = not accepted. ✗[1]= normally excluded but possibly suitable

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Figure 6-1 Example of communication tool around waste acceptance

Table 6-2 Summary of consultation and engagement activities since 2012

Year	Stakeholder	Milestone event	Feedback
2012	Department of Mines and Petroleum and Goldfields Land and Sea Council	Application for Exploration License lodged 25 May 2012	Application for an exploration lease was referred to the Goldfields Land and Sea Council (the recognised Native Title Representative Body for the Goldfields region) on 8 August 2012. No objections were lodged and there are no records of any claims affecting the area covered by Exploration Licence E16/440.
2012	Department of Mines and Petroleum	Exploration License granted	Exploration License (E16/440) granted 23 January 2013. The Company has the right to explore for minerals for five years, subject to the Company meeting its annual expenditure commitments. Three of the 20 sub-blocks overlaid the IWDF file notation areas (FNA* –set aside for future expansion). The proponent informed the Department of Finance, Building Management and Works that the proponent would complete no exploration over the three blocks overlapping the FNA. On 11 November 2013, the WA Government, DMP approved the stage one drilling program on E16/440.
2014	Traditional owners	Cultural heritage baseline investigations	Site walkovers with Traditional Owners concluded the proposed exploration development envelope is not constrained by items of known Aboriginal heritage. Heritage survey completed by experienced anthropologist.
February 2015	Traditional Owners and Anthropologist	Cultural heritage baseline investigations	On February 2015, the DMP approved the stage two drilling program on E16/440. A second site visit with Traditional Owners was undertaken to confirm the proposed development envelope is not constrained by items of known Aboriginal heritage. The results of the second walkover did not alter from the first site walkover. Heritage survey completed by experienced anthropologist. Stage two drilling program lasted three weeks and ended 21 March 2015.
March 2015	Traditional owners	Cultural heritage baseline investigations	A second site visit with Traditional Owners was undertaken to confirm the proposed development envelope is not constrained by items of known Aboriginal heritage. The results of the second walkover did not alter from the first site walkover.
October 2015	Decision Making Authorities	Pre-planning focus meeting[18]	The proponent received neutral to positive support for the Proposal. Stakeholders within government were interested in job creation and the potential for long-term job security as a result of the Proposal. Other issues raised included: • The design of the facility, particularly the acceptance and separation of chemical wastes from LLW.

[18] *Key decision making authorities who were represented at the meeting included the OEPA, DER, DMP, Department of Lands, DoEE*

Year	Stakeholder	Milestone event	Feedback
			• The type of waste to be accepted and not accepted. • The transport of waste materials to and from Perth and Kalgoorlie. • The level of interaction the proponent has undertaken with Traditional Owners.
November 2015	Government (State representatives)	Completion of pre-feasibility report	The issues raised by State government representatives were similar to those raised during the October pre-planning focus meeting.
February 2016	Coolgardie community	Draft ESD public review	Refer to Section 6.5.2.
February 2016	Kalgoorlie community	Draft ESD approved for public review	Refer to Section 6.5.2.
May 2016	Decision Making Authorities	Draft ESD comments following public review	**Radiological Council** required the proponent to define site selection characteristics by referencing recent studies to ensure compliance and suitability of site selection criteria under current legislative and best practice requirements. This has been addressed in Section 2.3. **Radiological Council** required the proponent to provide a summary of the history of waste acceptance of WA from across Australia with particular regard to WA Policy and the *Nuclear Waste Storage and Transportation (Prohibition) Act 1999* and its relationship to this proposal. This has been addressed in Chapter 4. **Radiological Council** requested the proponent to clarify the appropriate examples of wastes with concentrations below 3700 Bq/g^ and half-lives less than 30 years. This has been discussed in Section 10.6.4. **Conservation Council** requested the PER define 'nuclear waste' and 'radioactive waste' and describe the waste that would and would not be accepted. This has been addressed in Section 1.2.3. **General comments** – concerns from other Government and political sectors were raised relating to the potential for future acceptance of intermediate and high level waste. The proponent has not nominated the Proposal as a potential National Radioactive Waste Management Facility. The proponent is not planning to make such a nomination. The proponent would not accept a nomination should it be made by any other party.

Year	Stakeholder	Milestone event	Feedback
			Conservation Council raised the issue of transport of intractable, hazardous and low level radioactive wastes. The proponent has included an Operating Strategy for the Proposal (Appendix A.16). The Operating Strategy includes a high level description of components including management of transport contractors and waste contractors, and the proponent's standards for transport that need to be met, prior to waste deliveries being accepted at the Facility. **The Wilderness Society of WA** required the proponent to address potential impacts on the Great Western Woodlands and Helena and Aurora Range Conservation Park and potential regional cumulative impacts. This has been addressed in Section 10.3.2. The **OEPA** confirmed that an international peer review of the engineering design is required for the PER. The proponent has commissioned an independent peer review relating to the engineering design and storage components of the Facility (refer to Appendix A.21). The **Department of Health** required the proponent to address matters relating to drinking water and water quality monitoring. The proponent has addressed this in a site specific drinking water management plan (refer to Appendix A.20). The **Department of Aboriginal Affairs** required the proponent to submit a Heritage study. This has been addressed in Appendix A.13. The **Wilderness Society** requested the proponent to consult with Traditional Owners. This is covered in Section 10.7. **General comment** around mine closure and rehabilitation and costs associated with these activities were raised. The proponent has provided a MCP (Appendix A.19) and Decommissioning Plan (Appendix A.18). Costs associated with both closure and decommissioning are discussed in both appendices.

**File Notation Area*

^ Becquerels per gram

6.6 Future consultation

6.6.1 Overview

Continuous consultation is a commitment of the proponent and liaison would continue with non-government organisations, local politicians and other interested parties. The proponent maintains a stakeholder register and would continue to liaise with Traditional Owners, the community and key government departments throughout the life of the Proposal.

The proponent also places key community and regulatory related information on its website www.tellusholdings.com and shares news updates with interested stakeholders.

6.6.2 PER for public review

When the PER is released for public review, extensive consultation with the key stakeholders identified in Table 6-1 would be undertaken, particularly the communities of Southern Cross, Coolgardie and Kalgoorlie. Opportunities for online feedback would be available to the public via the EPA's website and the proponent's website.

Part C
Environmental Factors

7 ENVIRONMENTAL FACTORS AND PRINCIPLES

7.1 Key environmental factors

The key environmental factors identified in the ESD include:

- Flora and vegetation.
- Terrestrial environmental quality.
- Terrestrial fauna.
- Inland waters environmental quality.
- Human health.
- Heritage.
- Offsets (integrating factor).
- Rehabilitation and decommissioning (integrating factor).

In addition, amenity (in relation to noise, dust and visual impacts) as well as the water source and viability of the water source and cumulative impacts was considered relevant to the Proposal.

The assessment of potential environmental risks on the above factors are discussed in Chapter 10 and Chapter 11.

7.2 Principles of sustainability and environmental protection

The principles of the *Environmental Protection Act 1986* (Section 4A) and other principles adopted by the EPA as outlined in *Environmental Assessment Guideline for Environmental Principles, Factors and Objectives (EAG 8)* (2015a) guide the EPA's decision making on the environmental acceptability of the proposal. These principles have been considered in the preparation of this PER, as outlined in Table 7-1.

Table 7-1 Principles of sustainability and environmental protection

Principle	Application	PER reference
The precautionary principle *Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.* *In the application of the precautionary principle, decisions should be guided by:* *(a) Careful evaluation to avoid, where practicable, serious or irreversible damages to the environment;* *and* *(b) An assessment of the risk-weighted consequences of various options.*	Throughout the design of the Proposal, the precautionary principle has been applied, where potential impacts could cause serious or irreversible damage. The main example of the application of the precautionary principle is the threat of contamination of an aquifer. An aquifer has not been identified beneath the proposed development envelope, however, regardless of this, the following management and mitigation measures would be implemented to protect groundwater: • Installation of groundwater monitoring bores, and continual monitoring of these bores during the life of the Proposal. • Containment of wastes within cells designed to exclude water to prevent the generation of leachate. • Operational bunding and V drains around the cells to prevent water ingress into the cells. • Minimum separation distance of 5 m between the base of a cell and the underlying granite, which is more permeable. • Spill response procedures. • Subsidence monitoring and remedial measures to respond to slumping or erosion of the clay cap. These measures would be implemented to minimise the risk of groundwater contamination and demonstrate the application of the precautionary principle.	Section 10.5
The principle of intergeneration equity	LLW would be monitored during the institutional control period to ensure by the end of the ICP, radioactivity on the surface of the development	Section 5.13 Appendix A.14

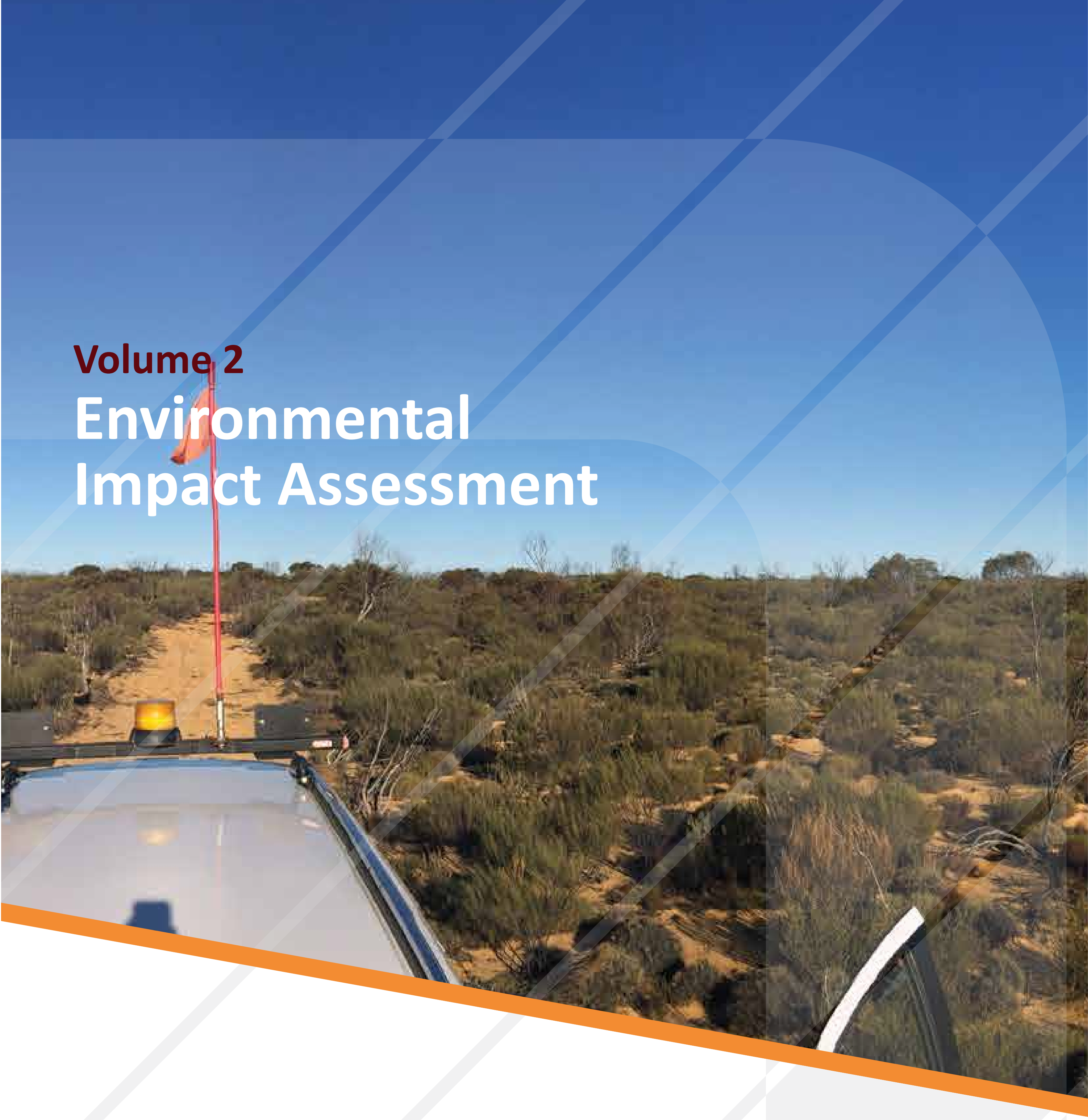
Principle	Application	PER reference
The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.	envelope is equivalent to background concentrations, thereby ensuring future generations would not be exposed to human health risks. Records of waste isolation would be held by key regulatory agencies and the State Archive to ensure future generations have access to information regarding the wastes isolated at Sandy Ridge.	Appendix A.17
The principle of the conservation of biological diversity and ecological integrity *Conservation of biological diversity and ecological integrity should be a fundamental consideration.*	The location for the Proposal has been chosen as it has the characteristics appropriate for a near surface geological repository. It is not proposed to remove or affect any conservation significant flora or fauna, communities or ecological linkages. The proposed clearing would not cause any of the vegetation communities present to become threatened in any way.	Section 1.3 and 10.2.5
Principles in relation to Improved valuation, pricing and incentive mechanisms *Environmental factors should be included in the valuation of assets and services.* *The polluter pays principle – those who generate pollution and waste should bear the cost of containment, avoidance or abatement.* *The users of goods and services should pay prices based on the full life cycles costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any wastes.* *Environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structures, including market mechanisms, which enable those best placed to maximise benefits and/or minimise costs to develop their own solutions and responses to environmental problems.*	The Proposal would provide waste generators with a cost-effective option to dispose of their hazardous and intractable waste. The only available option at present is cost prohibitive. The restrictive regulatory framework for the IWDF means that it is operated as a site of last resort for receiving waste and the onus is on the waste holder to demonstrate that they have exhausted all other potential options for handling the waste materials before they can be directed to the IWDF. This, coupled with the very high cost structures associated with each waste isolation campaign and the infrequent basis on which it operates means that the IWDF is a very unattractive disposal option for most waste generators. This is particularly so for those with smaller quantities of waste where the waste holder wishes to achieve permanent isolation in a reasonable timeframe. The Proposal would provide a cost-effective option, by offering significantly lower gate charges than the IWDF. This would encourage the correct permanent isolation of high risk hazardous and intractable wastes, eliminating a significant environmental risk to the community.	Section 2.4

Principle	Application	PER reference
The principle of waste minimisation *All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.*	Approximately 3.2 million tonnes of legacy waste are estimated to be temporarily stored in over 200 locations across Australia, awaiting an appropriate long-term storage option. The Proposal would minimise waste that is currently stored in temporary and often inappropriate storage locations, by providing a suitable near surface geological repository for permanent waste isolation.	Section 2.4.3.
Best practice *When designing proposals, and implementing environmental mitigation and management actions, the contemporary best practice measures available at the time of implementation should be applied.*	Best practice has also been implemented in the design of the waste cells by reviewing practices at international LLW disposal facilities and adhering to international and national codes for permanent isolation of LLW. It is considered best practice to prepare an outline Safety Case for a LLW disposal facility that would be developed into a detailed Safety Case after detailed design has been completed. The outline Safety Case is provided in Appendix A.15. Recommendations for environmental mitigation and management actions specified by technical experts have been included in this PER to eliminate or reduce the potential environmental impacts associated with the Proposal. An example of this is the need for surface water levees on the north and east boundaries of the proposed cell area, as recommended by Rockwater (2016b). The construction of levees is considered best practice to divert surface water runoff away from cells, and hence avoid the potential for leachate generation. Levees have thus been incorporated into the design of the Proposal.	Appendix A.10, A.12 and A.15
Continuous improvement *The implementation of environmental practices should aim for continuous improvement in environmental performance.*	Continuous improvement and corrective actions are of paramount importance, and are a fundamental part of the EMS. *	Section 12.

** Environmental management system*

Volume 2

Environmental Impact Assessment



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Part D
Approach to Environmental Assessment

8 ENVIRONMENTAL RISK ASSESSMENT

8.1 Risk assessment methodology

Environmental risk assessment is the process undertaken to identify, evaluate and mitigate potential environmental impacts of a proposed development. As the environmental assessment for the Facility included input from a wide range of technical disciplines, a Proposal based environmental risk assessment was undertaken to ensure consistency in determining the level of risks.

A standardised approach to evaluating significance of risks does not replace the methodologies used by technical disciplines to identify or assess impacts, nor does it replace methods of impact assessment prescribed by existing guidance. Rather, it adds to the impact assessment by providing clear, more readily comparable conclusions regarding the significance of impacts.

The risk assessment methodology has been devised by the proponent based upon the broad definitions, methodology and principles outlined in AS/NZS ISO 31000:2009. The standardised risk assessment for the Proposal involved the following steps:

8.1.1 Hazard identification

- The identification of potential environmental hazards associated with various components (‘aspects’) of the Proposal.
- Identifying the nature of the identified hazards (defined as ‘beneficial’, ‘neutral’ or ‘adverse’).

8.1.2 Pre-mitigation risk

- Assessing the ’likelihood’ of an identified hazard occurring.
- Defining the ‘consequence’ of the hazard occurring, as described by impacts of health and safety, environmental, financial, Proposal delivery or social impacts.
- As a product of the likelihood and consequence, determining the pre-mitigation composite risk index i.e. ‘risk’ (CRI = likelihood x consequence).

8.1.3 Identifying required mitigation

- Identifying the mitigation required to control the risk as a consequence of likelihood of the hazard.
- Identifying the mitigation required to control the risk as a consequence of the hazard.
- Documenting the owner of those mitigation actions, the time and cost implications and detailing a review date.

8.1.4 Post-mitigation risk

- Reassessing the ’likelihood’ of an identified hazard occurring in light of the implemented mitigation.
- Reassessing the ‘consequence’ of the hazard occurring in light of the implemented mitigation.
- As a product of the mitigated likelihood and consequence, determining the post-mitigation composite risk index i.e. ‘risk’. This is often termed as ‘residual risk’ or occasionally ‘current risk’.

The environmental and social systems, resources and receptors potentially affected by the Proposal were defined through desktop based research, field surveys and preliminary consultation with key agencies within the WA Government, regional stakeholders and local communities.

8.1.5 The nature of an identified hazard

By definition, a ‘hazard’ is described as a source of potential harm, but as the risk assessment methodology may be used to identify beneficial impacts in this context a ‘hazard’ is identified as impact of the Proposal of whatever nature). For the purposes of this assessment the following descriptors are used:

- **Beneficial**: The hazard has a potential beneficial impact upon the environment.
- **Neutral**: The hazard has neither a beneficial or adverse impact on the environment. Occasionally, the term ‘benign’ is used. Typically, a hazard would be categorised as having a neutral nature post-mitigation.
- **Adverse**: The hazard has a potentially adverse impact on the environment.

8.1.6 Evaluating likelihood

The likelihood of a hazard and an impact occurring can be described in terms of probability. Overlaying this is the need to recognise that uncertainty may be associated with potential risks occurring, particularly during the initial risk assessment process. Where scientific uncertainty exists, a precautionary approach was taken which identified a higher level of risk. Each identifiable impact can be assigned a likelihood of occurring, ranging from rare to almost certain.

In simplifying the potential impacts for the purpose of a risk assessment, an element of subjectivity is introduced. The purpose of the risk assessment is not necessarily to agree on the probability of any particular impact, but to facilitate an understanding of the relative probability of different impacts.

The pre-mitigation assessment of likelihood needs to account for the probability of an identified hazard occurring, assuming the incorporation of ‘designed-in’ mitigation that would be required to comply with legislation, relevant guidance, or otherwise which is intrinsic to the design specification upon which the development proposal has been based.

Columns two to four in Table 8-1 give descriptions that elaborate on the possible likelihood categories. These are presented to help view the impact from different perspectives.

Table 8-1 Likelihood of a hazard

Likelihood	Description	Probability	Mid-interval	Community outlook
Almost certain	Is expected to occur in most circumstances	0.91–1.00	0.95	Almost everyone affected
Likely	Would probably occur in most circumstances	0.61–0.90	0.75	Most people affected
Possible	Might occur at some time	0.41–0.60	0.50	Many people affected
Unlikely	Could occur at some time	0.11–0.40	0.25	Some people affected
Rare	May occur only in exceptional circumstances	0.01–0.10	0.05	Few or no people affected or interested

8.1.7 Evaluating consequence

To determine the consequence of potential impacts, clearly described thresholds were developed which included the scale of impact, its geographic extent, duration, ecological and social sensitivity, reversibility, cumulative effects and likelihood of occurrence.

In simplifying the potential impacts for the purpose of a risk assessment, an element of subjectivity is introduced. The purpose of the risk assessment is not necessarily to agree on the defined consequence of any particular hazard, but to facilitate an understanding of the relative impacts.

The pre-mitigation assessment of consequence needs to address the severity of an identified hazard occurring, assuming the incorporation of 'designed-in' mitigation that would be required to comply with legislation, relevant guidance, or otherwise which is intrinsic to the design specification upon which the development proposal has been based.

Table 8-2 give descriptions that elaborate on the possible consequence categories. These are presented to help view the impact from different perspectives.

Table 8-2 Consequence of a hazard

Descriptor	Description (examples)				
	Health	Environmental	Financial loss	Proposal delivery	Social
Catastrophic	Death	Toxic release offsite with detrimental effect	Cessation of production capability/huge financial loss	Proposal incapable of completion/Un viable	No social licence to operate
Major	Extensive injuries	Offsite release with no detrimental effects	Loss of production capability Major financial loss	Proposal can only be completed with major changes (redesign)	Reactive media plan, recovery plan, working committees
Moderate	Medical treatment required	Onsite release contained with outside assistance	High financial loss	Proposal can be completed with moderate changes	Additional meetings
Minor	First aid treatment	Onsite release immediately contained	Medium financial loss	Proposal can be completed with changes	Additional local engagement
Insignificant	No injuries	None	Low financial loss	Trivial	Insignificant

8.1.8 Evaluating risk

The risk of an identified hazard (sometimes also called the 'significance') was determined as a product of the likelihood of the hazard and its consequence on the environment, resource, social value or receptor that it would potentially impact, or as a consequence to the delivery of the Proposal, assuming that the mitigation required to comply with legislation, relevant guidance and the design specifications for the Proposal have been implemented.

In order to standardise the significance rating assigned to potential environmental impacts, a matrix was developed and two multi-disciplinary workshops were held by key members of the environmental assessment team in May and October 2015 and again in April 2016.

A generic set of risk criteria is defined (refer to Table 8-3) and enables a consistent description of both adverse and beneficial impacts. In each chapter, the significance criteria are made relevant to the topic being considered.

Table 8-3 Generic significance criteria

Significance	Criteria
Extreme	These impacts are considered critical to the decision making process. They tend to be permanent, or irreversible, or otherwise long term, and can occur over large scale areas. These effects are generally but not exclusively associated with sites and features of and/or the impacts of national importance. Typically, mitigation measures are unlikely to remove such effects.
High	These impacts are likely to be of importance in the decision making process. They tend to be permanent, or otherwise long to medium term, and can occur over large or medium scale areas. Environmental receptors are high to moderately sensitive, and/or the impacts are of state significance.
Medium	These impacts are relevant to decision making, particularly for determination of environmental management requirements. These impacts tend to range from long to short term, and occur over medium scale areas or focused within a localised area. Environmental receptors are moderately sensitive, and/or the impacts are of regional or local significance.
Low	These impacts are recognisable, but acceptable within the decision making process. They are still important in the determination of environmental management requirements. These impacts tend to be short term, or temporary and at the local scale.
Eliminated	As a result of mitigation, the likelihood and/or the consequence has been removed.

8.1.9 Risk assessment matrix

Based on the assessment of likelihood and consequence, any foreseeable impact can be assigned a risk rating. The environmental assessment is at this point intended to focus on potentially significant environmental risks and impacts.

Table 8-4 is to be read as a matrix, with increased consequence across the top and increased likelihood on the far left column. Any potential impacts that fall in the top left of the matrix are therefore addressed as *key environmental issues requiring detailed environmental assessment* in the PER. Impacts that fall into the bottom right of the matrix are addressed as *other issues* in the PER.

Table 8-4 Risk matrix

Consequence / Likelihood	Eliminated	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	Eliminated	High	High	High	Extreme	Extreme
Likely	Eliminated	Medium	Medium	High	High	Extreme
Possible	Eliminated	Low	Medium	Medium	High	High
Unlikely	Eliminated	Low	Low	Medium	Medium	High
Remote	Eliminated	Low	Low	Low	Medium	Medium
Eliminated	Eliminated	Eliminated	Eliminated	Eliminated	Eliminated	Eliminated

8.1.10 Duration

This assessment also requires consideration of the duration of the impact (refer to Table 8-5) and any relevant EPBC Act Significant Impact Guidelines for Matters of National Environmental Significance.

Table 8-5 Relative duration of environmental effects

Duration of environmental effects	Period
Temporary	Days to months
Short-term	Up to 1 year
Medium-term	From 1 to 5 years
Long-term	From 5 to 50 years
Permanent/irreversible	Over multiple generations

8.1.11 Uncertainty

The uncertainty of risk is evaluated according to the following descriptors:

- **Low**: the risk has been determined through quantitative assessment procedures, or is determined to a high degree by a person with adequate skill and experience to make the assessment.
- **Medium**: the risk has been evaluated through qualitative assessment and represents a reasonable estimate of risk under normal circumstances.
- **High**: the risk is largely unknown.

8.1.12 Potential impacts

The initial risk assessment takes into consideration outline management and mitigation measures including design changes within the development of the proposal. The residual risk assessment takes into consideration additional mitigation measures identified as necessary to lower the significance, frequency or risk of an impact occurring.

The results of the environmental risk assessment for the Proposal are contained within Appendix A.2. This combined with the OEPA's guidelines for the preparation of a PER and the contents of the ESD identified the key issues for consideration.

8.2 Mitigation identification and residual impact assessment

Once the pre-mitigation risks were determined, relevant mitigation measures were developed. Key considerations for the preferred mitigation measures were to:

- Be appropriate in terms of effort and expense to the scale and nature of the impact.
- Target the protection and/or restoration of the resources affected.
- Respond to the appropriate level in the 'mitigation hierarchy' i.e. avoid > minimise > rehabilitate > manage > offset/compensate.
- The level of mitigation measures proposed should respond to the significance of the relevant impacts identified. For example:
  - An impact considered to be of extreme significance (where not simply considered grounds for a fundamental re-design of the Proposal) would need to be met with a high level of mitigation that avoids, eliminates or makes provisions for full offsetting or

compensation in advance and ensures that measures are demonstrably effective. Compliance with international and national standards and the use of specialists with internationally or nationally recognised expertise would be required in development and implementation. A high level of ongoing monitoring would be required.

- Conversely an impact that was considered to be of low significance may either not need mitigation at all or only require management by control of impacts through day to day management with only occasional monitoring required as validation.

Table 8-6 provides a summary of the approach that was implemented when developing mitigation and management measures. This approach ensured that the level of mitigation proposed for each impact was appropriate and in proportion to the level of impact significance.

Once mitigation and management measures were identified, residual impacts were assessed. As previously stated, the pre-mitigation risk assessment assumes the incorporation of 'designed-in' mitigation that is required to comply with legislation, relevant guidance, or otherwise which is intrinsic to the design specification upon which the development proposal has been based.

This was achieved through assessing and describing the effects of mitigation and subsequently, how the proposed measures would reduce: (i) the likelihood of the hazard; and/or (ii) the consequence of the hazard.

8.3 Indirect impacts

Indirect impacts were considered within the environmental assessment for the Proposal. For example, vibration effects from the blasting of geological strata during mine shaft construction may permanently dislodge rocks on surrounding hills which may in turn have adverse impacts on cultural heritage or landscape and visual amenity. Each technical discipline considered both direct and indirect impacts of the Proposal by undertaking the following steps:

- Clearly identifying the cause/effect relationships between each action and impact.
- Taking a conservative approach by assuming the most significant likely magnitude of the relevant impact.
- Clearly stating factors affecting the worst case and likely case outcomes.

Table 8-6 Management and mitigation measures

Initial impact significance rating	Mitigation response
Extreme	Risks must be designed out, eliminated or fully offset or compensated with offset and/or compensation measures in place before the Proposal proceeds. International and national standards would need to be complied with and specialists with internationally or nationally recognised expertise should be involved in development and implementation of mitigation and offsetting. High level of ongoing monitoring is required to confirm effectiveness of mitigation measures and whether additional mitigation or other corrective actions are required.
High	High impacts must be avoided wherever possible and otherwise offset or fully compensated. An environmental bond must be in place. Ongoing monitoring is recommended to confirm effectiveness of mitigation and management measures.
Medium	Management of impact would be required and closely monitored to check that impacts are not more severe than predicted. Replacement may be required where consequence of the action on resources of low or moderate value is extreme (i.e. complete loss of the resource). Rehabilitation of disturbed areas is likely and monitoring required to check effectiveness of mitigation measures.
Low	Management of impacts should be addressed in day to day management. Monitoring may be required to validate that impacts are low.
Eliminated	No mitigation or management is typically required.

8.4 Cumulative impacts

Cumulative impacts can be defined as impacts on the environment, which result from the incremental impact of an action when added to other past, present or reasonably foreseeable future actions, regardless of what agency or person undertakes those other actions (Carroll and Turpin 2009).

Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time or from a combination of concurrent effects from a single action. They can be additive, synergistic or interactive and can result in impacts that are larger, more significant and longer lasting than is the case with individual impacts and their effects.

There is no defined process for undertaking cumulative impact assessments (CIA) within Australia. Considerations related to cumulative impacts are included in the Commonwealth Environment Protection and Biodiversity Conservation Regulations 2000.

The above Regulations state the need to assess cumulative impacts in relation to World Heritage Areas and Ramsar sites but do not provide any guidance on scoping and carrying out CIA. Table 8-7 describes the approach taken for the Proposal in determining potential cumulative impacts.

Table 8-7 Cumulative impact methodology

Method	Comment
Spatial boundaries	Setting boundaries is the process of establishing the limits of the area to be assessed for cumulative impacts and the identification of activities within this boundary. The primary spatial boundary for the CIA is the Propsal footprint – this is the area that is under project control and responsibility, i.e. the Proposal Area. However, boundaries can vary from issue to issue and need to reflect ecosystem requirements rather than artificial boundaries.
Temporal boundaries	Cumulative impacts during the construction phase are likely to be short-term and localised to the Proposal footprint and immediate surrounds. Operation phase impacts are more likely to be medium to long-term (e.g. continuing for more than two years after the activity has ceased, or ongoing) and to extend beyond the Proposal footprint.
Proposal approach	Cumulative impacts have been addressed separately within each of the individual chapters in order to reflect the differing spatial and temporal boundaries of each environmental aspect.

Part E
Existing Environment

9 EXISTING ENVIRONMENT

9.1 Flora and vegetation

The proposed development envelope is located in the Coolgardie Interim Biogeographic Regionalisation of Australia (IBRA) Bioregion which covers the interzone between mulga and spinifex country and eucalypt environments over an area of approximately 12,912,204 ha (DoE, 2015b, DPAW, 2014).

Within the Coolgardie IBRA Bioregion, the proposed development envelope is located in the Southern Cross subregion that is 6,010,832 ha in size (DoE, 2015b and DPAW, 2014). DPAW (2014) estimates approximately 5,773,838 ha of the current extent of pre-European vegetation remains in the sub-region.

The Southern Cross subregion comprises the western section of the Yilgarn Craton and is characterised as gently undulating uplands dissected by broad valleys with bands of low greenstone hills (Cowan *et al*., 2001). The granite strata of the Yilgarn Craton are interrupted by parallel intrusions of Archaean Greenstone.

Diverse Eucalyptus woodlands that include species such as *Eucalyptus salmonophloia, Eucalyptus salubris, Eucalyptus transcontinentalis* and *Eucalyptus longicornis* are common in the region. Granite basement outcrops occur at mid-levels in the landscape and support grasslands of *Borya constricta*, intermixed with stands of *Acacia acuminata* and *Eucalyptus loxophleba*. Areas with a slightly higher elevation in the landscape include the eroded remnants of yellow sandplains, gravelly sandplains and laterite breakaways. Mallees including *Eucalyptus leptopoda*, *Eucalyptus platycorys* and *Eucalyptus scyphocalyx* and scrub heaths (*Allocasuarina corniculata, Callitris preissii, Melaleuca uncinata* and *Acacia beauverdiana*) occur on these uplands (Cowan *et al.*, 2001).

9.1.1 Vegetation associations

Most of the vegetation within the proposed development envelope belongs to Beard vegetation association 437 'Shrublands; mixed acacia thicket on sandplain'. The south-western area (along the proposed water pipeline route and access road) belongs to Beard vegetation association 141 'Medium woodland; York gum, salmon gum and gimlet'.

Vegetation in the water pipeline route and access road areas are mostly Beard vegetation association 437 with some 141. The south-western end of the water pipeline route also contains Beard vegetation association 538 '*Eucalyptus* open woodland/*Triodia* open hummock grassland' and a small area of 435 '*Acacia* sparse shrubland/*Cryptandra* mixed sparse heath'. All of these vegetation associations have a low reservation priority for ecosystems.

Vegetation associations within the proposed development envelope and vicinity are shown on Figure 9-1.

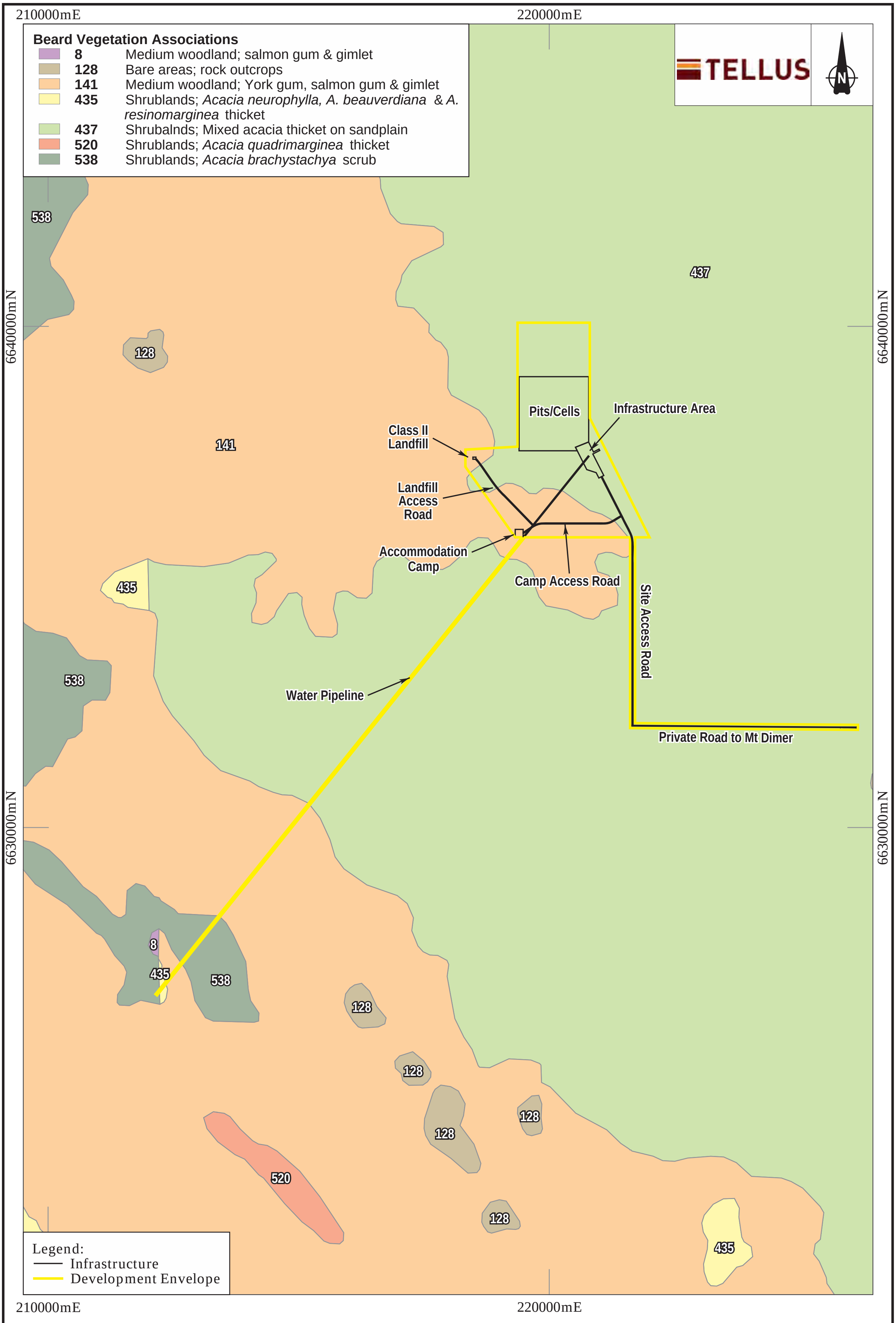
9.1.2 Vegetation types

A range of different vegetation types were described and mapped within the proposed development envelope (refer to Figure 9-2a and Figure 9-2b). Many of the vegetation types intergrade and could be considered variations of the main types. All of the vegetation types are considered common and widespread within the wider region. A description of the vegetation types including their assigned codes are provided below. A flora species list is provided in Appendix A.3.

Acacia resinimarginea Open Heath (Ar)

This is one of the most dominant vegetation types within the proposed development envelope. *Acacia resinimarginea* is consistently 1–1.2 m high and 40–50% cover (refer to Plate 9-1). Other common species include *Phebalium filifolium*, *Phebalium canaliculatum*, *Homalocalyx thryptomenoides*, *Melaleuca uncinata* and *Callitris preissii*. The *Callitris preissii* plants are small seedlings approximately 0.2–0.3 m high that are regenerating after a fire that occurred several years ago in the area. Spinifex (*Triodia scariosa*) is also common but at a low density. The soils are light yellow to orange-brown loamy sands.

Plate 9-1 *Acacia resinimarginea* Open Heath

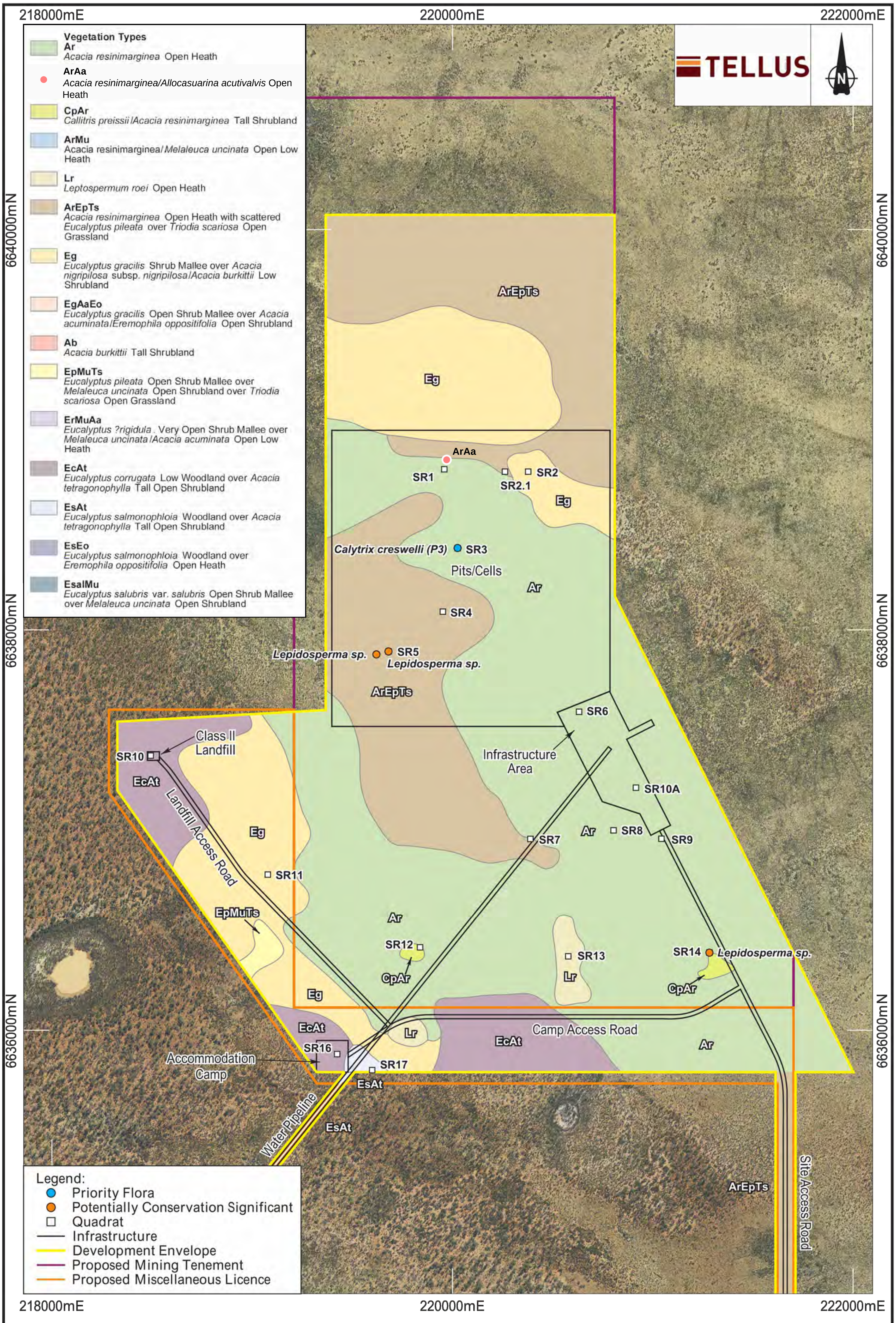


0 1.5km
Scale 1:100,000
MGA94 (Zone 51)
CAD Ref: g2294_PER_07_10.dgn
Date: November 2016 | Rev: C | A4

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

Sandy Ridge Facility
Vegetation associations within the proposed development footprint
Public Environmental Review

Figure: **9-1**



0 400m

Scale 1:25,000
MGA94 (Zone 51)

CAD Ref: g2294_PER_07_11.dgn

Date: November 2016 | Rev: C | A4

Author: C. Dorrington | AE Ref: THO2014-003

Drawn: CAD Resources ~ www.cadresources.com.au
Tel: (08) 9246 3242 ~ Fax: (08) 9246 3202

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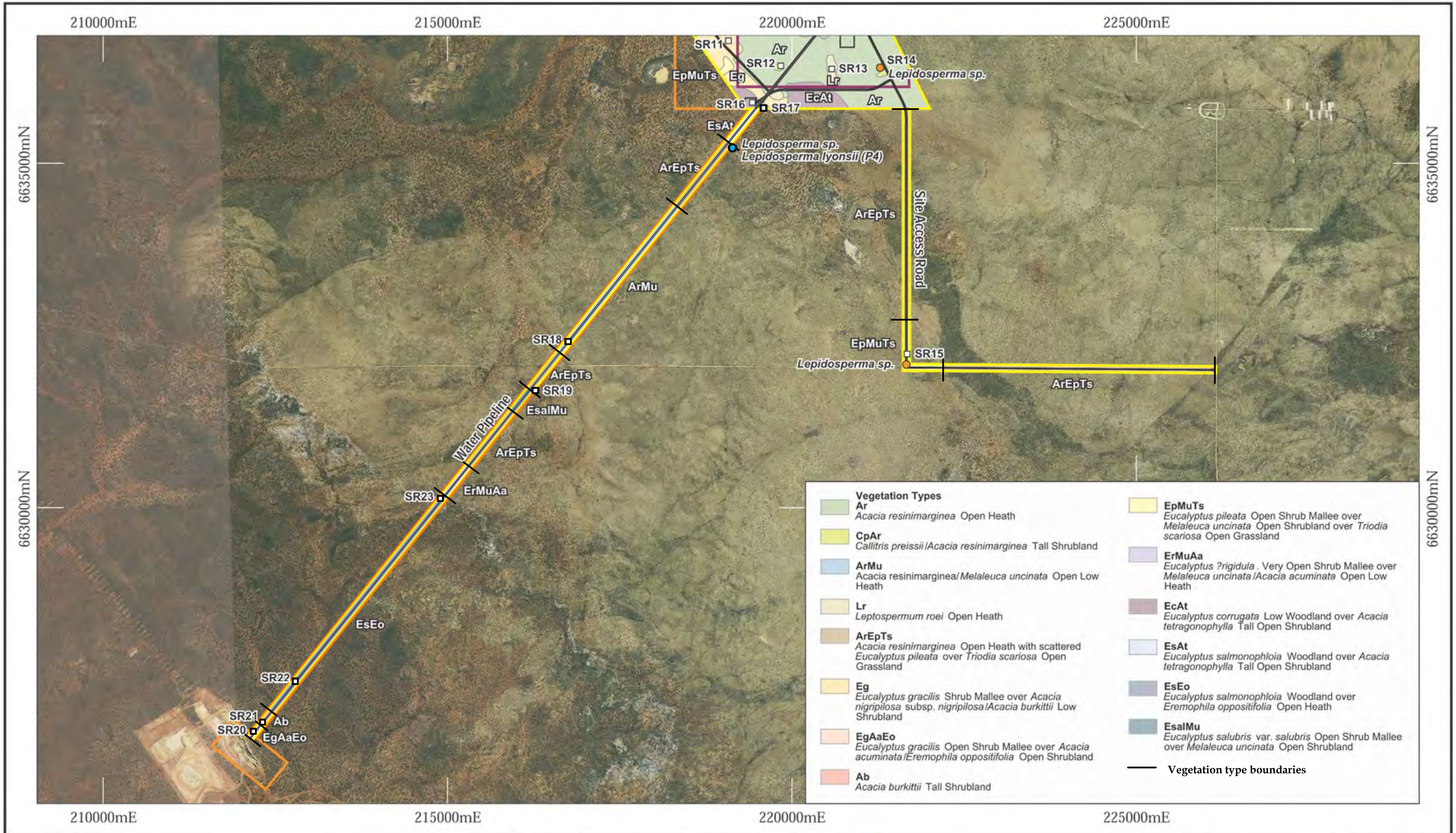
Vegetation types within the proposed development envelope

Public Environmental Review

Figure:

9-2a



Legend:
- Priority Flora
- Potentially Conservation Significant
- Quadrat
- Infrastructure
- Development Envelope
- Proposed Mining Tenement
- Proposed Miscellaneous Licence

TELLUS

0 15km
Scale 1:75,000
MGA94 (Zone 51)
CAD Ref: g2294_PER_07_14.dgn
Date: Nov 2016 Rev: C A4

Aurora environmental

Author: C. Dorrington AE Ref: THO2014-003
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Sandy Ridge Facility
Vegetation types within the proposed development envelope
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Figure: **9-2b**

Callitris preissii/Acacia resinimarginea Tall Shrubland (CpAr)

This vegetation type is essentially a variety of the *Acacia resinimarginea* Open Heath (Ar) vegetation type that escaped a fire that occurred several years ago in the area. It is located in two pockets within the southern portion of the proposed development envelope (refer to Plate 9-2). The *Callitris preissii* trees are up to 3-4 m high and the *Acacia resinimarginea* and *Melaleuca uncinata* up to 2-2.5 m high. *Homalocalyx thryptomenoides* is a common small shrub. The soils are light yellow-brown loamy sands.

Plate 9-2 *Callitris preissii/Acacia resinimarginea* Tall Shrubland

Acacia resinimarginea/Allocasuarina acutivalvis Open Heath (ArAa)

A small pocket (approximately 20 m by 20 m) of this vegetation type occurs at the northern end of the proposed cell. It is very similar in structure and composition to the *Acacia resinimarginea* Open Heath (Ar) vegetation type but contains *Allocasuarina acutivalvis* which is virtually absent from the *Acacia resinimarginea* Open Heath (Ar) vegetation type (refer to Plate 9-3). The presence of ironstone pebbles at the surface of the loamy sand may be a reason for the occurrence of *Allocasuarina acutivalvis* in this area.

Plate 9-3 *Acacia resinimarginea/Allocasuarina acutivalvis* Open Heath

Acacia resinimarginea/Melaleuca uncinata Open Low Heath (ArMu)

This vegetation type occurs on the water pipeline route just north of the existing road to Mount Dimer. *Acacia resinimarginea* and *Melaleuca uncinata* co-dominate at around 1 m in height and 20-25% cover each (refer to Plate 9-4). The vegetation is slightly more species rich than the *Acacia resinimarginea* Open Heath (Ar) vegetation and sub-units within the proposed development envelope. The soils are light orange-brown loamy sand with ironstone pebbles at the surface.

Plate 9-4 *Acacia resinimarginea/Melaleuca uncinata* Open Low Heath

Leptospermum roei Open Heath (Lr)

This vegetation type occurs in the southern portion of the proposed development envelope. *Leptospermum roei* dominates this vegetation type, growing up to around 1.8 m in height with 50% cover. There is little to no *Acacia resinimarginea* present (refer to Plate 9-5). The composition of the smaller shrubs is similar to the *Acacia resinimarginea* Open Heath (Ar) vegetation type with *Homalocalyx thryptomenoides* common. The soils are yellow loamy sand.

Plate 9-5 *Leptospermum roei* Open Heath

Acacia resinimarginea Open Heath with scattered Eucalyptus pileata over Triodia scariosa Open Grassland (ArEpTs)

This is another widespread vegetation type occurring on the yellow loamy sand soils, particularly in the central and northern parts of the proposed development envelope. The shrub cover is less dense at 25-40% which has allowed the Spinifex (*T. scariosa*) to grow in higher densities, around 20–25% cover. The Small Mallee (*Eucalyptus pileata*) occurs sporadically throughout this vegetation type. Other common species include *Phebalium filifolium, Homalocalyx thryptomenoides* and *Keraudrenia integrifolia.* At the time of the field survey, *Callitris preissii* was present as seedlings in some areas but only occurred as old dead plants with no seedlings evident in large areas (refer to Plate 9-6). The soils are light orange-brown loamy sand.

Plate 9-6 *Acacia resinimarginea* Open Heath with scattered *Eucalyptus pileata* over *Triodia scariosa* Open Gr

Eucalyptus pileata Open Shrub Mallee over Melaleuca uncinata Open Shrubland over Triodia scariosa Open Grassland (EpMuTs)

This vegetation type is located in the south-east portion of the proposed development envelope and is similar to the *Acacia resinimarginea* Open Heath with scattered *Eucalyptus pileata* over *Triodia scariosa* Open Grassland (ArEpTs) with the exception that *Acacia neurophylla* is the dominant *Acacia. S*everal other species not commonly recorded elsewhere in the proposed development envelope such as *Melaleuca eleuterostachya, Hakea francisiana* and *Podolepis capillaris* were present and indicated a transition from the vegetation within the proposed development envelope to that further east (refer to Plate 9-7). The soils are light orange-red sand.

Plate 9-7 *Eucalyptus pileata* Open Shrub Mallee over *Melaleuca uncinata* Open Shrubland over *Triodia scariosa* Open Grassland

Eucalyptus gracilis Shrub Mallee over Acacia nigripilosa subsp. nigripilosa/Acacia burkittii Low Shrubland (Eg)

This vegetation type occurs on harder sandy loam soils on slightly more elevated land in the western and northern portions of the proposed development envelope. *Eucalyptus gracilis* is the main tree or mallee species present in densities around 10-40% (refer to Plate 9-8). *Acacia* species including *A. burkittii* and *A. nigripilosa* subsp. *nigripilosa* are common shrubs as is *Melaleuca uncinata, Alyxia buxifolia, Olearia muelleri* and *Scaevola spinescens.* There is a large percentage of bare ground present within this vegetation type, as shown in Plate 9-8. The soils are hard, red-orange sandy loam.

Plate 9-8 *Eucalyptus gracilis* Shrub Mallee over *Acacia nigripilosa* subsp. *nigripilosa/Acacia burkittii* Low Shrubland

Eucalyptus gracilis Open Shrub Mallee over Acacia acuminata/Eremophila oppositifolia Open Shrubland (EgAaEo)

This vegetation type occurs at the southern end of the water pipeline route close to the Carina Pit. The vegetation is located in a slight depression which may lead to slightly moister surface soils after rain. The shrub mallees are up to 4 m high and open over an open shrub layer consisting of *Acacia acuminata* and *A. tetragonophylla* as well as *Eremophila oppositifolia, E. maculata* and *Senna artemisioides* (refer to Plate 9-9). The soils are orange-red sandy loam with ironstone pebbles with a large percentage of bare ground.

Plate 9-9 *Eucalyptus gracilis* Open Shrub Mallee over *Acacia acuminata/Eremophila oppositifolia* Open Shrubland

Acacia burkittii Tall Shrubland (Ab)

A small band of this vegetation type occurs near the southern end of the water pipeline route in a low valley. *Acacia burkittii* is the dominant taller shrub up to 3 m high and averaging 20% although it can be denser in places (refer to Plate 9-10). *Grevillea eriostachya* up to 1.3 m is also present. Common smaller shrubs include *Leucopogon* sp. Clyde Hill and *Homalocalyx thryptomenoides*. The soils are orange-red sandy loam with ironstone pebbles at the surface.

Plate 9-10 *Acacia burkittii* Tall Shrubland

Eucalyptus rigidula Very Open Shrub Mallee over Melaleuca uncinata/Acacia acuminata Open Low Heath (ErMuAa)

This vegetation type occurs on top of a small rise on perhaps the highest part of the water pipeline route between the Carina Pit and existing road to Mount Dimer. *Eucalyptus rigidula* (no buds or fruit) commonly occurs as a shrub mallee in very low densities. The shrub layer is dominated by *Melaleuca uncinata* with *Acacia acuminata* and *Senna artemisioides* common (refer to Plate 9-11). The soils are orange-red sandy loam.

Plate 9-11 *Eucalyptus rigidula* Very Open Shrub Mallee over *Melaleuca uncinata*/*Acacia acuminata* Open Low Heath

Eucalyptus corrugata Low Woodland over Acacia tetragonophylla Tall Open Shrubland (EcAt)

This vegetation type is located in the south-western portion of the proposed development envelope and consists of large tracts of typical Goldfields Eucalypt Woodland with *Eucalyptus corrugata* the dominant species up to 8 m high and with an open canopy cover of 10-25% (refer to Plate 9-12). Common understorey species include *Acacia tetragonophylla, Santalum acuminatum, Exocarpos aphyllus, Scaevola spinescens, Acacia colletioides, Phebalium filifolium* and *Austrostipa nitida.* The soils are orange-brown loamy sand.

Plate 9-12 *Eucalyptus corrugata* Low Woodland over *Acacia tetragonophylla* Tall Open Shrubland

Eucalyptus salmonophloia Woodland over Acacia tetragonophylla Tall Open Shrubland (EsAt)

This vegetation type also occurs in the south-western part of the proposed development envelope mixed in with the *Eucalyptus corrugata* Low Woodland over *Acacia tetragonophylla* Tall Open Shrubland (EcAt). Salmon Gum *(E. salmonophloia)* is sparse and up to 12 m high over a tall open shrubland containing similar common species to the EcAt vegetation type such as *Acacia tetragonophylla, Acacia colletioides, Scaevola spinescens* and *Olearia muelleri* (refer to Plate 9-13). The soils are orange-red sandy loam.

Plate 9-13 *Eucalyptus salmonophloia* Woodland over *Acacia tetragonophylla* Tall Open Shrubland

Eucalyptus salmonophloia Woodland over Eremophila oppositifolia Open Heath (EsEo)

This species is common along the southern portion of the water pipeline route. Superficially this vegetation type looks structurally the same as the *Eucalyptus salmonophloia* Woodland over *Acacia tetragonophylla* Tall Open Shrubland (EsAt) with Salmon Gum the main species present up to 12 m high and 20% cover over an open understorey. However, the understorey composition is quite different and contains Chenopod species *(Atriplex vesicaria, Maireana georgei, Sclerolaena densiflora)* that are absent from the proposed development envelope. *Eremophila* species *(E. oppositifolia, E. pantonii)* are common in the understorey (refer to Plate 9-14)**.** The soils are orange-red sandy loam.

Plate 9-14 *Eucalyptus salmonophloia* Woodland over *Eremophila oppositifolia* Open Heath

Eucalyptus salubris var. salubris Open Shrub Mallee over Melaleuca uncinata Open Shrubland (EsalMu)

A small stand of Gimlet *(Eucalyptus salubris* var. *salubris)* occurs on the water pipeline route south of the road to Mount Dimer. The Gimlet mallees are up to 5 m high and in low density. *Melaleuca uncinata*, *Senna artemisioides* and *Acacia resinimarginea* are common shrub species and the native grasses *Aristida contorta* and *Austrostipa nitida* occur together. Grass species were very sparse throughout the survey area (refer to Plate 9-15).

Plate 9-15 *Eucalyptus salubris* var. *salubris* Open Shrub Mallee over *Melaleuca uncinata* Open Shrubland

The area of each vegetation type within the proposed development envelope is provided in Table 9-1.

Table 9-1 Area and percentage of vegetation types within the proposed development envelope

Vegetation type code	Vegetation type name	Area within proposed development envelope (ha)	Percentage within proposed development envelope (%)
Ab	*Acacia burkittii* Tall Shrubland	0.98	0.10
Ar	*Acacia resinimarginea* Open Heath	434.18	43.24
ArAa	*Acacia resinimarginea/Allocasuarina acutivalvis* Open Heath	0.04	<0.01
ArEpTs	*Acacia resinimarginea* Open Heath with scattered *Eucalyptus pileata* over *Triodia scariosa* Open Grassland	295.57	29.43
ArMu	*Acacia resinimarginea/Melaleuca uncinata* Open Low Heath	10.91	1.09
CpAr	*Callitris preissii/Acacia resinimarginea* Tall Shrubland	2.19	0.22
EcAt	*Eucalyptus corrugata* Low Woodland over *Acacia tetragonophylla* Tall Open Shrubland	60.44	6.02
Eg	*Eucalyptus gracilis* Shrub Mallee over *Acacia nigripilosa* subsp. *nigripilosa/Acacia burkittii* Low Shrubland	150.86	15.02
EgAaEo	*Eucalyptus gracilis* Open Shrub Mallee over *Acacia acuminata/Eremophila oppositifolia* Open Shrubland	0.91	0.09
EpMuTs	*Eucalyptus pileata* Open Shrub Mallee over *Melaleuca uncinata* Open Shrubland over *Triodia scariosa* Open Grassland	15.59	1.55
ErMuAa	*Eucalyptus rigidula* Very Open Shrub Mallee over *Melaleuca uncinata/Acacia acuminata* Open Low Heath	2.22	0.22
EsalMu	*Eucalyptus salubris* var. *salubris* Open Shrub Mallee over *Melaleuca uncinata* Open Shrubland	1.62	0.16
EsAt	*Eucalyptus salmonophloia* Woodland over *Acacia tetragonophylla* Tall Open Shrubland	4.42	0.44
EsEo	*Eucalyptus salmonophloia* Woodland over *Eremophila oppositifolia* Open Heath	16.11	1.60
Lr	*Leptospermum roei* Open Heath	8.16	0.81
Total		**1004.2**	**100%**

9.1.3 Vegetation condition

Using the vegetation condition rating scale devised by Keighery (1994) and described in Bush Forever (Government of Western Australia, 2000) (Table 9-2) most of the vegetation within the proposed development envelope is considered to be in 'excellent' condition.

Table 9-2 Vegetation condition rating scale

Condition	Description
Pristine	Pristine or nearly so, no obvious signs of disturbance.
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
Very good	Vegetation structure altered obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
Completely degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species.

9.1.4 Vegetation of conservation significance

Three Priority Ecological Communities (listed as Priority 1 by DPAW) were identified as potentially occurring within the vicinity of the proposed development envelope. These include:

- Finnerty Range/Mt Dimer/Yendilberin Hills vegetation complexes (banded ironstone formation).
- Hunt Range vegetation complexes (banded ironstone formation).
- Lake Giles vegetation complexes (banded ironstone formation).

These communities are all associated with the banded iron formation which does not occur within the proposed development envelope. Additionally, the interpreted vegetation types recorded within the proposed development envelope are not representative of these Priority Ecological Communities.

There are no Threatened or Endangered Ecological Communities listed under the WC Act or Threatened or Endangered Ecological Communities listed under the EPBC Act within the proposed development envelope.

9.1.5 Flora species of conservation significance

Fifty flora species listed under the WC Act and/or EPBC Act or by DPAW have been recorded or are predicted to occur within the proposed development envelope or within the locality (refer to Table 9-3). Thirty-two of these species were considered as possibly occurring within the proposed development envelope. The remaining species were considered unlikely to occur due to a lack of suitable habitat and, therefore, would not be affected by the Proposal.

Two of the 32 species considered as possibly occurring within the proposed development envelope were recorded during the field surveys. These were *Calytrix creswellii* and *Lepidosperma lyonsii* (both listed as Priority 3 by DPAW). These species are discussed further below. The remaining 30 species considered as possibly occurring within the proposed development envelope were not recorded during the field surveys, and therefore would not be affected by the Proposal.

An undescribed sedge species was also recorded within the proposed development envelope – *Lepidosperma* sp. This species is currently undescribed and may have some conservation value. This species is also discussed below.

Calytrix creswellii

Calytrix creswellii was recorded at one location in *Acacia resinimarginea* Open Heath (Ar) in the middle of the proposed cells (refer to Plate 9-10 and Figure 9-2a). *Calytrix creswellii* is currently known to occur within the Coolgardie and Murchison bioregions of the Eremaean Province (DPAW, 2015). It has previously been recorded on nearby sites including the Mount Walton East IWDF (Ecologia Environmental Consultants, 1997), the IWDF Access Road (Mattiske Consulting Pty Ltd, 2012) and on the site of the Carina Iron Ore Project (Recon Environmental, 2010). The Mattiske Consulting Pty Ltd (2012) survey recorded many separate populations of the species with population sizes greater than 50.

Lepidosperma lyonsii

Lepidosperma lyonsii was recorded on the proposed water pipeline route between the existing road to Mount Dimer and the Proposal surface infrastructure area (refer to Plate 9-11 and Figure 9-2b). *Lepidosperma lyonsii* is known to occur in several locations in the Coolgardie Botanical District and has previously been recorded on the site of the Carina Iron Ore Project (Recon Environmental, 2010) and the IWDF Access Road (Mattiske Consulting Pty Ltd, 2012).

Lepidosperma sp.

An undescribed sedge species was recorded within the proposed development envelope – *Lepidosperma* sp. The species was not considered to be any of the conservation significant species previously recorded in the vicinity of the proposed development envelope (as listed in Table 9-3). Five populations of this species were recorded in vegetation dominated by *Acacia resinimarginea* (refer to Figure 9-2a and Figure 9-2b). The species is likely to be more widespread within the proposed development envelope than the populations recorded. In their survey of the yellow sandplain vegetation on the Mt Walton Road to the south of the proposed development envelope, Mattiske Consulting Pty Ltd (2012) recorded 13 species of *Lepidosperma* which were not able to be identified to species level mostly due to the species being undescribed. The taxonomy of the *Lepidosperma* sp. is currently being reviewed by the WA Herbarium. Until those results are published, the *Lepidosperma* sp. recorded within the proposed development envelope has been treated as potentially having some conservation value.

Table 9-3 Conservation significant flora known to occur near the proposed development envelope and likelihood of it occurring within the proposed development envelope

Species	WA status[19]	Status under EPBC Act 1999[20]	Habitat	Likelihood of occurring within the proposed development envelope
Myriophyllum lapidicola **Chiddarcooping Myriophyllum**	Threatened	Endangered	Ephemeral pools 20 cm to 50 cm deep on granite outcrops.⁺	Unlikely
Ricinocarpos brevis	Threatened	Endangered	Shallow sandy soils on rocky banded ironstone outcrops.®	Unlikely
Tetratheca paynterae **Paynter's Tetratheca**	Threatened	Endangered	Rock crevices, in shallow pockets of soil of rich red loam.®	Unlikely
Cryptandra polyclada subsp. aequabilis	Priority 1	-	Sand.	Possible
Cyathostemon sp. Mt Dimer **(C. McChesney TRL 4/72) PN**	Priority 1	-	Yellow sand.	Possible
Dampiera sp. Jaurdi **(D. Angus DA 268) PN**	Priority 1	-	Associated species: *Allocasuarina corniculata*, *Gyrostemon racemiger*, *Acacia sibina*, *Eucalyptus leptopoda* subsp. *subluta*, *Calytrix creswellii* ~ Interpreted habitat: Yellow sand, gravel, sandplains.	Possible
Lepidosperma sp. Parker Range **(N. Gibson & M. Lyons 2094)**	Priority 1	-	Recorded on ridge/slope. Well-drained. Dry brown clay loam over granite. 10–30% of loose rock on soil surface.#	Unlikely
Leucopogon sp. Yellowdine **(M. Hislop & F. Hort MH**	Priority 1	-	Recorded on Flat. Moist yellow sand. Burnt >5 years.^	Unlikely
Phebalium appressum	Priority 1	-	Yellow sandplain.	Possible
Tecticornia flabelliformis	Priority 1	-	Clay. Saline flats.	Highly unlikely

[19] Priority species are listed by the DPAW. Threatened species listed under the *Wildlife Conservation Act 1950* (WA)
[20] *Environment Protection and Biodiversity Conservation Act 1999* (Cth)

Species	WA status[19]	Status under EPBC Act 1999[20]	Habitat	Likelihood of occurring within the proposed development envelope
Xanthoparmelia fumigata	Priority 1	-	Recorded on ridge with bare to littered, stoney crusted brown clayey sand.[<]	Unlikely
Baeckea sp. Jaurdi Station (L.W. Sage & F. Hort 2229)	Priority 2	-	Light brown-yellow sand. Sandplains.	Possible
Daviesia sarissa subsp. redacta	Priority 2	-	Yellow sand. Plains.	Possible
Elachanthus pusillus	Priority 2	-	Open depression in plain system. Sandy clay loam.[&]	Unlikely
Goodenia jaurdiensis	Priority 2	-	Red clayey loam with laterite or banded ironstone gravel or quartz pebbles. Low-lying plains and lower slopes.	Possible
Hakea rigida	Priority 2	-	Sandy soils, yellow sand.	Possible
Hemigenia tenelliflora	Priority 2	-	Sandplain.[@]	Possible
Lissanthe scabra	Priority 2	-	Dry, white to orange-brown clay, sandy gravel loams, granite. Breakaways, uplands.	Unlikely
Malleostemon sp. Adelong (G.J. Keighery 11825)	Priority 2	-	Red sand.	Unlikely
Acacia cylindrica	Priority 3	-	Yellow/brown sand, gravelly soils. Undulating plains, flats.	Possible
Acacia desertorum var. nudipes	Priority 3	-	Yellow sand, lateritic gravel. Sandplains, flats.	Possible
Austrostipa blackii Crested Spear-grass	Priority 3	-	Recorded on a gentle upper North slope. Brown loam over red loam with granite fragments at 5 cm.[%]	Unlikely
Banksia lullfitzii	Priority 3	-	Yellow sand. Sandplains.	Possible
Bossiaea celata	Priority 3	-	Deep sand. Open mallee.	Possible

Species	WA status[19]	Status under EPBC Act 1999[20]	Habitat	Likelihood of occurring within the proposed development envelope
Calytrix creswellii	Priority 3	-	Yellow sand, sometimes with lateritic gravel. Sandplains.	Possible (subsequently recorded during field surveys)
Cyathostemon verrucosus	Priority 3	-	Flat yellow sandy clay plain.>	Unlikely
Eucalyptus exigua	Priority 3	-	Sandy loam, white sand. Sandplains.	Possible
Eutaxia actinophylla	Priority 3	-	Red-brown clay loam, red clay loam over granite, gravel. Small depressions.	Unlikely
Gastrolobium semiteres	Priority 3	-	Deep yellow sand, yellow to brown sandy clay, gravel, granite. Broad sand dunes, around rocks, undulating plains.	Possible
Gnephosis intonsa ***Shaggy Gnephosis***	Priority 3	-	Red/brown clay, stony saline loam.	Unlikely
***Gnephosis sp. Norseman* (K.R. Newbey 8096)**	Priority 3	-	Sub-saline loam. Moderately exposed flat.	Unlikely
Gompholobium cinereum	Priority 3	-	Yellow sand, clayey sand, brown loam, sandy gravel, laterite. Well-drained open sites, slopes, plains, roadsides.	Possible
Grevillea georgeana	Priority 3	-	Stony loam/clay. Ironstone hilltops and slopes.	Possible
Hibbertia lepidocalyx* subsp. *tuberculata	Priority 3	-	Yellow-orange loam, ironstone gravel.	Possible
Homalocalyx grandiflorus	Priority 3	-	Yellow sand. Sandplains.	Possible

Species	WA status[19]	Status under EPBC Act 1999[20]	Habitat	Likelihood of occurring within the proposed development envelope
Labichea eremaea	Priority 3	-	Red sand.	Unlikely
Lepidium genistoides	Priority 3	-	Sandy loam.	Possible
***Melichrus sp. Bungalbin Hill* (F.H. & M.P. Mollemans 3069)**	Priority 3	-	Yellow sandplain.=	Possible
Mirbelia ferricola	Priority 3	-	Recorded on skeletal red loam soils on massive banded iron formation.“	Possible
Stenanthemum newbeyi	Priority 3	-	Clayey sand, clay or loam over laterite or ironstone. Hillslopes.	Possible
Stylidium choreanthum **Dancing Triggerplant**	Priority 3	-	White/yellow or red sand. Plains.	Possible
Verticordia mitodes	Priority 3	-	Yellow sand. Undulating plains.	Possible
Verticordia stenopetala	Priority 3	-	Yellow sand, sometimes with gravel. Undulating plains.	Possible
Lepidosperma lyonsii	Priority 3	-	Orange skeletal sandy loam with banded ironstone gravel and rock, well-drained shallow stony loamy with quartz. Gentle hill slopes, upper slopes of large hill.	Possible (subsequently recorded during field surveys)
Banksia arborea **Yilgarn Dryandra**	Priority 4	-	Stony loam. Ironstone hills.	Possible

Species	WA status[19]	Status under EPBC Act 1999[20]	Habitat	Likelihood of occurring within the proposed development envelope
Eremophila caerulea subsp. merrallii	Priority 4	-	Sand, clay or loam. Undulating plains.	Possible
Eucalyptus formanii	Priority 4	-	Red sand. Ironstone slopes.	Possible
Grevillea erectiloba	Priority 4	-	Gravelly loam. Lateritic ridges.	Unlikely
Haegiela tatei	Priority 4	-	Clay, sandy loam, gypsum. Saline habitats.	Unlikely
Sowerbaea multicaulis **Many Stemmed Lily**	Priority 4	-	Yellow-brown sand.	Possible

** Sourced from Florabase (DPAW, 2015) unless otherwise annotated as per the list below*
® DoE SPRAT Database (DoE, 2015c)
+ Patten and Brown (2004)
~ Western Australian Herbarium (2015a)
 # Western Australian Herbarium (2015b)
^ Western Australian Herbarium (2015c)
< Western Australian Herbarium (2015d)
& State Herbarium of South Australia (2015a)
@ Western Australian Herbarium (2015e)
% State Herbarium of South Australia (2015b)
> Australian National Herbarium (2015)
= Western Australian Herbarium (2015e)
"National Herbarium of New South Wales (2015)

9.2 Terrestrial environmental quality

This section discusses climate, rainfall, temperature, evaporation and evapotranspiration, wind speed and direction, land use, topography, geology and soils within the proposed development envelope.

9.2.1 Climate

The proposed development envelope is located within a 'semi desert Mediterranean' climate and averages approximately 250 mm of rainfall per annum (Beard, 1990). The closest BoM weather station to the proposed development envelope is located at Menzies, approximately 110 km to the northeast.

An Automated Weather Station (AWS) was setup within the proposed development envelope in May 2015 (refer to Plate 9-16). It has recorded hourly average data since 8 May, 2015. The AWS collects the following data on a continuous basis:

- Wind speed at 10 m.
- Wind direction at 10 m.
- Relative humidity at 2 m.
- Air temperature at 2 m.
- Precipitation.

The climatic pattern during the warmer months of November to April is influenced by anticyclonic systems to the south-east. This means the proposed site is subjected mostly to easterly winds, clear skies and hot days. Occasionally during the above months, the southern extension of the Intertropic Convergence Zone may bring thunderstorm activity with impressive lightning displays and some rain (Pringle et al., 1994).

Plate 9-16 The Sandy Ridge automated weather station

Sporadic high intensity rainfall can also occur in the summer months as a result of remnant tropical cyclones that cross the coast between Carnarvon and Port Hedland. These track south-easterly, weakening to rain-bearing troughs or depressions between the usual anticyclone patterns (Pringle *et al*., 1994). Strong wind gusts can be associated with these depressions.

Maximum temperatures during these summer months often exceed 40°C and evaporation levels average over 2000 mm per annum (BoM, 2015a). Humidity levels are generally low and dews are rare (Pringle et al., 1994).

The climatic pattern during the cooler months (May to October) is still predominantly influenced by anticyclone systems. These tend to be centred further to the south and reach their northern extent over WA. As a result, the area is characterised to a large extent by cooler temperatures, cloudless skies and light south to south-easterly winds. This pattern is periodically interrupted by the passage of low pressure systems moving in from the west or south-west which result in bursts of north-westerly or westerly winds. These depressions often bring rain and are the main source of rain for south-western Australia.

The proposed development envelope is located sufficiently far enough to the north and east from the coast that these rainfall events are seldom intense. This synoptic pattern generally results in mild daytime temperatures and cold nights in the region.

Minimum temperatures during these months can drop below 0°C, although the mean is generally around 7°C. Evaporation levels are greatly reduced during the wetter months of May and June and humidity is generally highest in June and July.

9.2.2 Rainfall

The average annual rainfall for Menzies is 250 mm and the annual median rainfall is 244.4 mm. Rainfall is irregular and there may be extensive periods with no significant falls of rain. On average, rain falls most in February (probably as a result of remnant cyclones), with the next highest falls on average occurring in June, March and May respectively. On average, there about 32 rain days per year with June and July having the highest number of rain days at about four.

October has the least number of rain days at about two, so there is little variation in the number of rain days per month (BoM, 2015a). Slightly more rain falls on average (53%) in the summer months than in the winter months (47%).

The AWS recorded a total of 304.2 mm of rainfall from May 2015 to April 2016, with the highest fall recorded in January, and the next highest falls in February, March and August. This is consistent with long-term trends from the Menzies weather station to the north-east. Less than 1 mm of rain was recorded in May and September.

During the 2015-16 recording period, more rainfall occurred in the summer months (132.2 mm) than the winter months (76.2 mm). The distribution of rainfall is presented in Figure 9-3. The distribution of rainfall at Sandy Ridge is presented in Table 9-4. Maximum daily rainfall of 53.8 mm was observed during the summer, with the average rainfall during the summer months being the highest of all seasons. Lowest maximum and daily average rainfall was observed during the spring months at the Proposal site.

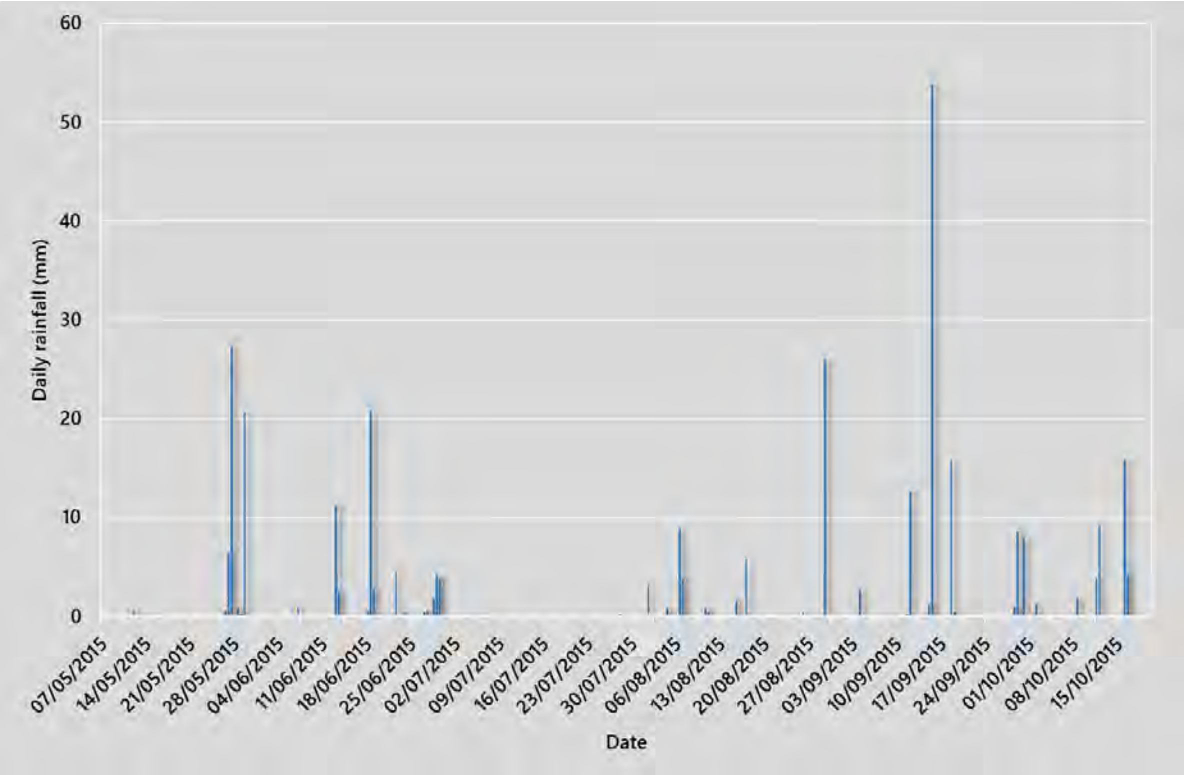

Figure 9-3 Daily average rainfall recorded at Sandy Ridge

Table 9-4 Seasonal rainfall recorded at Sandy Ridge between May 2015 and April 2016

Season	Daily rainfall (mm)		
	Maximum	Average	Minimum
Annual	**53.8**	**0.9**	**0.0**
Spring	8.8	0.3	0.0
Summer	53.8	1.8	0.0
Autumn	15.8	0.6	0.0
Winter	27.2	1.2	0.0

9.2.3 Temperature

Air temperatures measured at the proposed site between 7 May 2015 and 4 April 2016 varied between a minimum of 0.4 °C and a maximum of 42.1 °C. The average temperature measured over the monitoring period was 19.0 °C. Average maximum and minimum hourly temperatures measured during each season at the Proposal site are presented in Table 9-5.

Table 9-5 Observed temperatures at Sandy Ridge between May 2015 and April 2016

Season	Temperature (° C)		
	Maximum	Average	Minimum
Annual	**42.1**	**19.0**	**0.4**
Spring	39.7	20.3	0.8
Summer	42.1	25.1	9.7
Autumn	38.5	18.4	1.0
Winter	28.3	11.7	0.4

The daily average temperature calculated between 7 May 2015 and 4 April 2016 is presented in Figure 9-4 along with the observed range in daily temperature. As expected, maximum daily average and maximum temperatures occur during the summer months with a daily average temperature of 25.1 °C observed. Average air temperatures during the winter months is 11.7 °C but during the daytime hours have reached up to 28.3 °C during the year of measurement. The coldest temperature observed over the period was 0.4 °C in winter 2015.

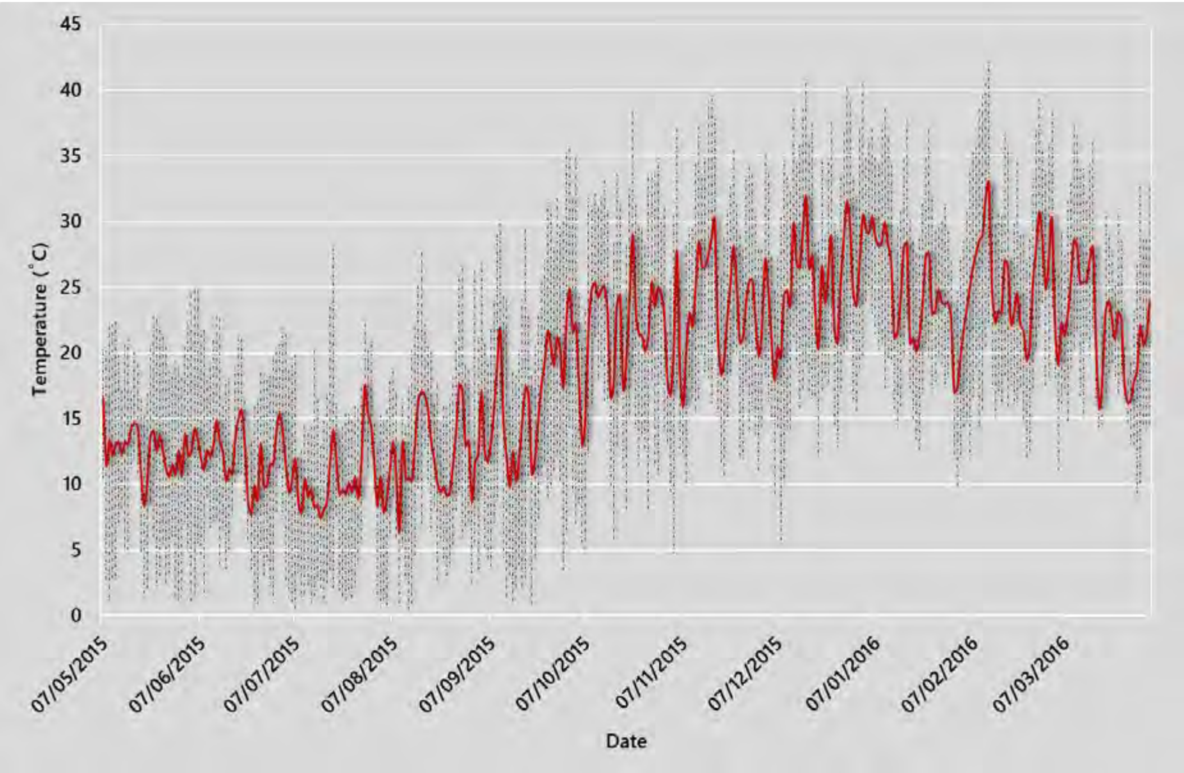

Figure 9-4 Daily average air temperatures at Sandy Ridge recorded between May 2015 and April 2016

9.2.4 Evaporation and evapotranspiration

Average evaporation at the proposed development envelope is between 2400 mm and 2800 mm per annum, based on 10 years of records from 1975 to 2005 (BoM, 2015b). Pan Evaporation is based on the amount of water evaporating from bare ground. Evaporation from land surfaces covered by vegetation is better estimated by evapotranspiration. Average areal actual evapotranspiration at the site is 300 mm per annum, based on 30 years of data from 1961 to 1990 (BoM, 2015c). Both evaporation and evapotranspiration averages per annum exceed the annual rainfall received at the site by approximately eight times, demonstrating it is a very dry environment.

9.2.5 Wind speed and direction

Annual and seasonal wind roses for wind data collected from the AWS between 7 May 2015 and 4 April 2016 are presented in Figure 9-5. The distributions of wind speed in a number of categories, including calm winds are presented in Figure 9-6. The wind roses indicate that over the course of the year, winds were predominantly observed from the east/north-east to south-easterly directions. The majority of wind speeds experienced at the development envelope generally ranged from 1.5 metres per second (m/s) to 8.0 m/s (frequency of 78% combined) with the highest wind speeds (>10.5 m/s) occurring from a west and west-north-westerly direction. Winds of this speed were rare and occurred for approximately 0.1% of hours across the year (eight hours). Calm winds (<0.5 m/s) occurred during 1.8% of the observed hours during the year. The wind roses show seasonality in wind speeds and direction as described below:

- **Spring** – Winds were predominantly experienced from the north-east to south-east directions. Wind speeds were typically in the range of 3.0 m/s to 8.0 m/s (frequency of 48.6%) and 1.5 m/s to 3.0 m/s categories (frequency of 30%). High wind speeds (8.0 m/s to > 10.5 m/s) occurred for a frequency of 0.6% of the year (13 hours in total) with the strongest winds (>10.5 m/s) occurring for 0.3% of the season (6.5 hours in total). Calm winds were experienced for 1.3% of observed hours.
- **Summer** – There was an observed decrease in the frequency of lighter winds (0.5 m/s to 3 0 m/s), and an increase in the frequency of wind speeds > 3.0 m/s to 8.0 m/s when compared to other seasons. The strongest winds (> 8.0 m/s) did not increase in frequency however the frequency of these wind speed categories were comparable to those experienced in all other seasons. Wind directions in the summer months were predominantly from easterly directions. The incidence of generally higher wind speeds in summer months was reflected in the low incidence of calm wind speeds (0.2%).
- **Autumn** – there was an observed increase in wind speeds in the 1.5 m/s to 3.0 m/s categories when compared with all other seasons, with a combined frequency of 84%. Distribution of wind directions is similar to those observed during summer months, although a higher frequency of winds from a south-easterly direction was experienced during the autumn. Calm winds were experienced for 1.1% of hours during the autumn months.
- **Winter** – a reduction in the frequency of winds originating from the east is observed during the winter months when compared to all other seasons. Lighter winds (1.5 m/s to 3.0 m/s) prevailed within the proposed development envelope in winter (43.9%). There was a reduction in the observation of higher wind speeds when compared with all other seasons, with no winds of greater than 8.0 m/s being recorded. An increase in calm wind speeds was also observed in winter months, with 4.4% of the recorded hours being less than 0.5 m/s (approximately 96 hours during the season).

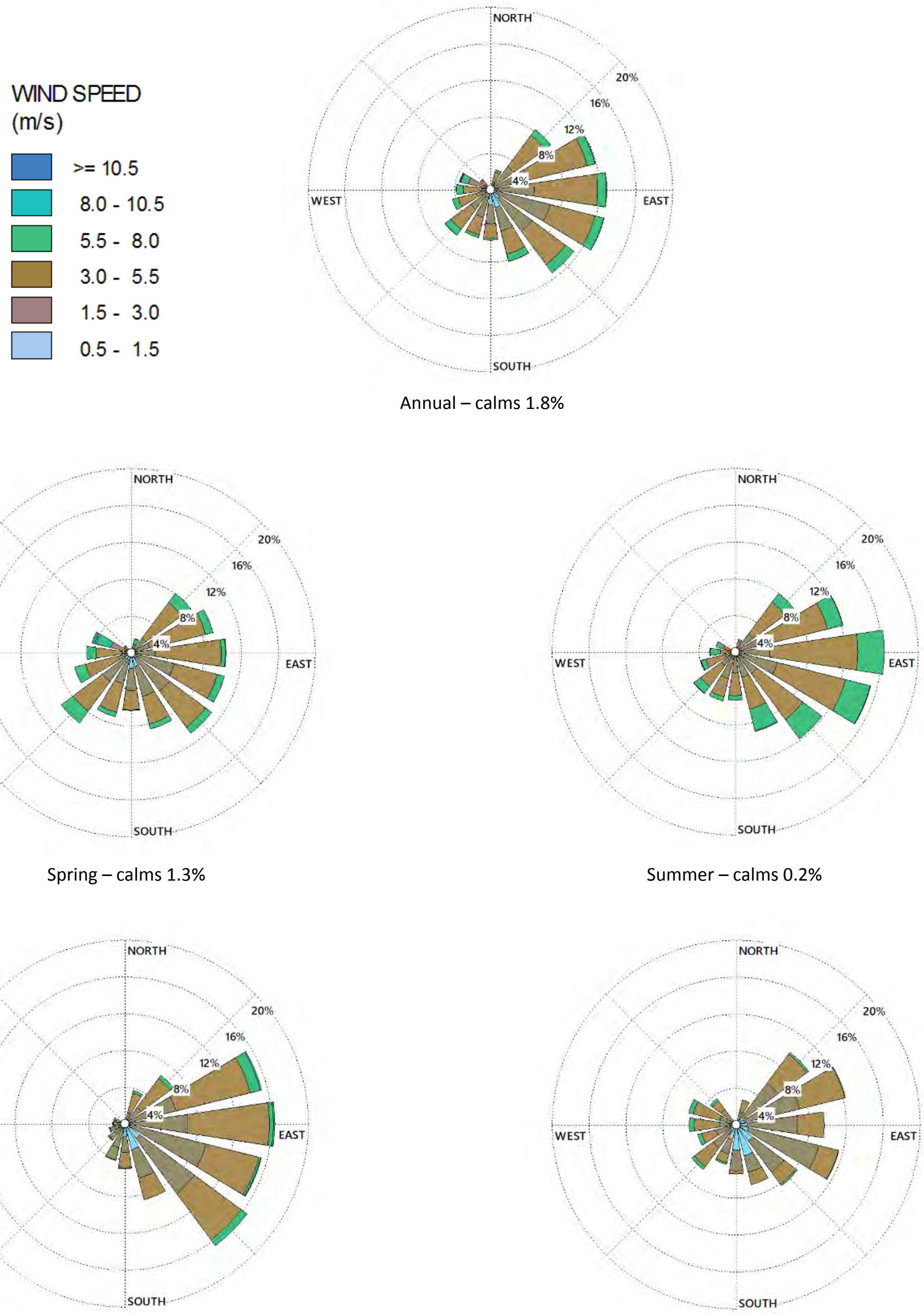

Figure 9-5 Annual and seasonal wind roses recorded at Sandy Ridge between May 2015 and April 2016

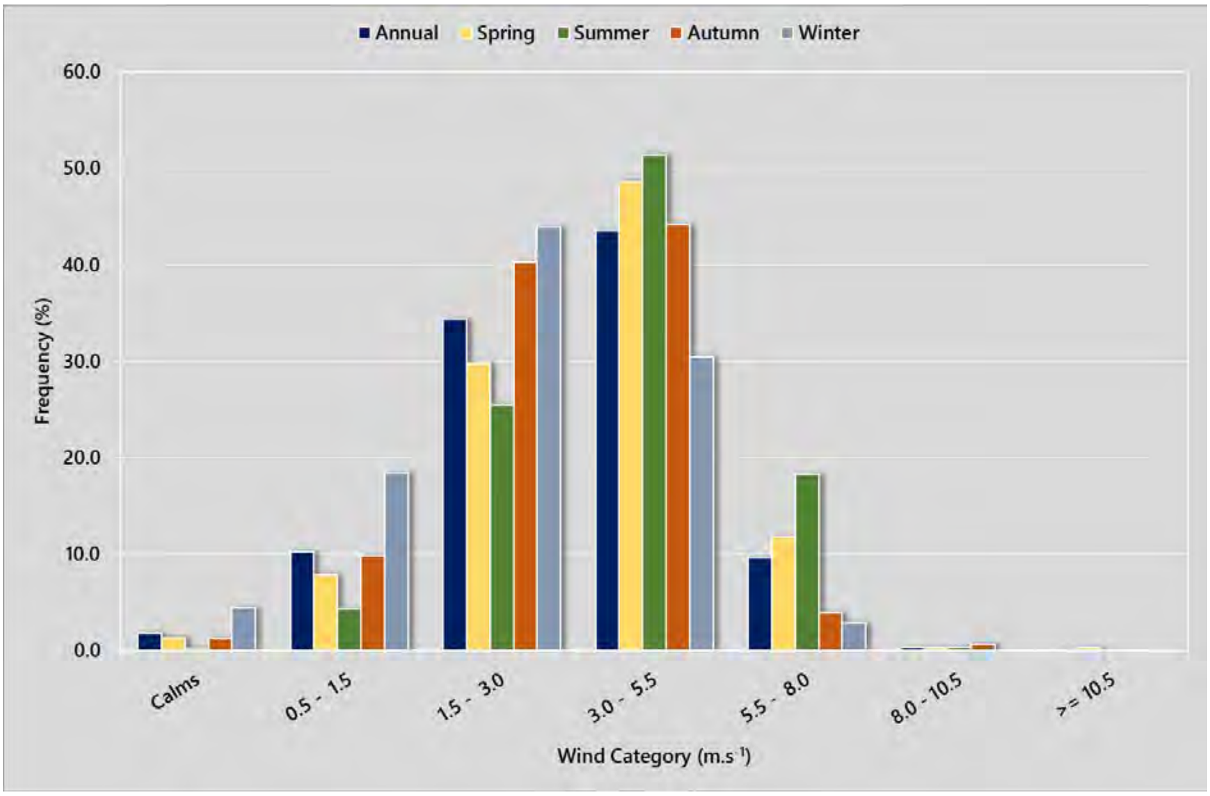

Figure 9-6 Annual and seasonal wind distribution at Sandy Ridge between May 2015 and April 2016

9.2.6 Land use

The land within the proposed development envelope is currently vacant, undisturbed Crown land. The water pipeline route would traverse a portion of the former Jaurdi Pastoral Lease, managed by the DPAW. There are several DPAW managed lands which are located within the vicinity of the proposed development envelope, as shown on Figure 9-7. These are:

- Mount Manning Range Nature Reserve, located approximately 9.8 km to the north-west.
- Mount Manning – Helena and Aurora Ranges Conservation Park, located approximately 19.8 km to the west.
- Boorabbin National Park, located approximately 100 km to the south.

The location of the proposed development envelope is remote. The nearest permanent residents are tourists staying at the Jaurdi Homestead (approximately 51 km away) and residents of the Carina Iron Ore Mine Accommodation Village (approximately 52 km away). Residents at the Carina Iron Ore Mine Accommodation Village are only present whilst the mine is operational.

An area to the east of the proposed development envelope, known as File Notation Area (FNA) 667, was set aside for the expansion of the IWDF. The FNA boundary is shown on Figure 9-7. Establishment of infrastructure such as a camp, works area or fuelling depot in the FNA area is prohibited unless permission is granted by the DMP and Department of Finance (Building Management and Works).

Two additional FNA areas; FNA 275 and FNA 668, are 15 km (radius) buffers from the IWDF, which have similar restrictions on land use to FNA 667. However, permission has been granted from the Department of Finance (Building Management and Works) that components of the Proposal could be established in these areas (approval letter dated 9 December 2015 can be provided on request).

9.2.7 Topography

The proposed development envelope has very low relief. It consists of flat to gently undulating plains and low rises and is typical of landscape which occurs over deeply weathered granite rocks. The topography ranges from about 460 m above sea level to 490 m above sea level and generally rises slightly from west to east (refer to Figure 9-7).

The proposed development envelope falls within the Kalgoorlie Province defined by Tille (2006). The Kalgoorlie Province is described as consisting of an extensive plateau of low relief that includes:

- Flat to undulating plains with small valleys (occasionally broken by low narrow rocky hills, ridges, tors and bosses) most commonly found on granitic terrain.
- Broad, flat to undulating, shallow valley plains are below these undulating plains and are formed on Quaternary alluvium and colluvium.
- Gently sloping to undulating plateau areas on granites and gneisses are situated higher in the landscape. These have long gentle slopes and, in places, abrupt erosional scarps.
- Rocky ranges, hills and ridges on the greenstone, along with some undulating to low hilly country.
- Level to gently undulating sandplains and gravelly sandplains are mostly found over lateritic residuals and granitic basement.
- The Yendilberin Hills which fall within the rocky ranges, hills and ridges of the greenstone category comprise a narrow, approximately north-west to south-west-trending rocky ridge to the west of the proposed development envelope, with a maximum elevation of 523 m AHD at Mount Walton (approximately 16 km south of the proposed development envelope (i.e. mining tenement), and approximately 8 km southeast of the Carina Pit and water pipeline route.

The proposed development envelope predominantly consists of flat to gently undulating sand plains and over weathered granite. There are no salt lakes in the proposed development envelope and the southern end of the water pipeline route near Carina Pit enters the Yendilberin Hills.

9.2.8 Regional geology

The proposed development envelope lies within the Archean Yilgarn Craton that comprises an area of approximately 657,000 km^2 and forms one of the largest intact segments of the Archean crust on Earth (CRM, 2016). The bulk of the craton is thought to have formed between 3,000 and 2,600 million years ago, with some gneissic terranes exceeding 3,000 million years in age (Anand and Butt, 2010).

The surface of the Yilgarn Craton, the Yilgarn Plateau, has low relief and, on a regional scale, probably represents a Proterozoic[21] erosion surface. This extremely old surface has subsequently been modified by weathering, partial erosion, and sedimentation, resulting in a complex regolith[22] (Anand and Butt, 2010). Broad landforms have been in place for about 250 million years and the Yilgarn Craton has been tectonically stable for approximately 2,500 million years.

The geological history of the proposed development envelope involved the emplacement of a granitic body within the earth's crust about 2,700 million years ago (Nelson, 2002). Over the next 2000 million years the overlying rocks were eroded, resulting in a relatively flat landscape, which has been above sea level for at least the last 540 million years, during which time it has been subject to various weathering events as it has undergone different climatic regimes (CRM, 2016).

The Yilgarn Craton can be subdivided into four provinces (Gee *et al*.,1981); the Western Gneiss Terrane, the Murchison Province, the Southern Cross Province and the Eastern Goldfields Province. The proposed development envelope lies in the Southern Cross Province, but is very close to the western boundary of the Eastern Goldfields Province (Geological Survey of Western Australia, 1990).

9.2.9 Local geology

The geology underlying the proposed development envelope is shown on Figure 9-8 which displays interpreted bedrock geology. Table 9-6 shows the drilling history in and around the proposed Sandy Ridge site.

The data within Table 9-6 shows that since the granting of an exploration licence, 202 holes have been drilled across the proposed development envelope between 2014 and 2016. This equates to 5,607 m of geological data which has been used to infer physical and chemical characteristics of the kaolin, and to prove the site lacks groundwater.

The proposed development envelope is located in the centre of a 160 km long and 20 km wide north-north-west trending granitic body, which intruded older granitic and volcanic rocks (CRM, 2016).

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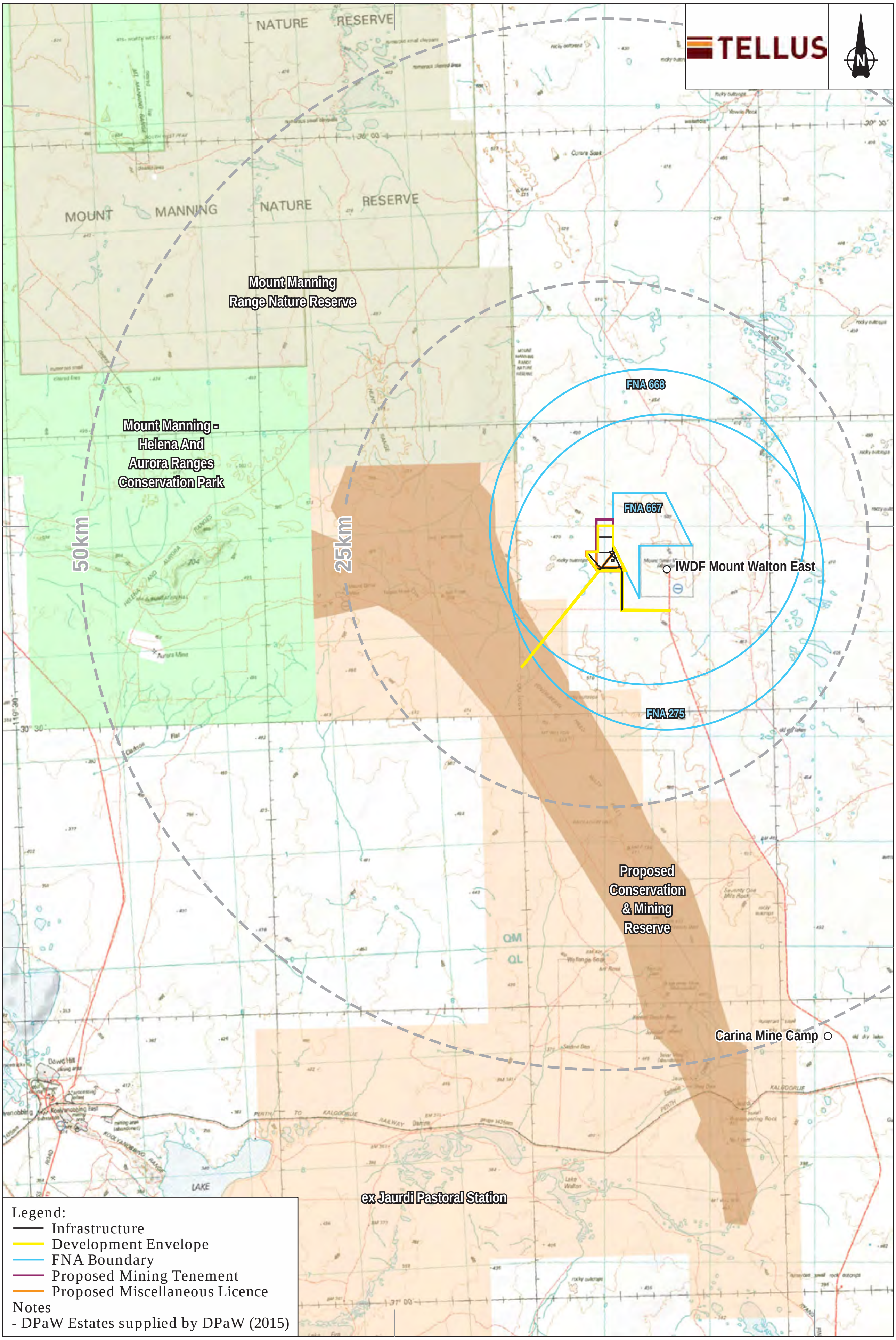
[21] *The Proterozoic is that period of time between approximately 2500 and 540 million years ago.*
[22] *The regolith is the combination of weathered rock, soil, and other unconsolidated or cemented material that forms a younger blanket over unweathered bedrock.*



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Landuse

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Figure: **9-7**

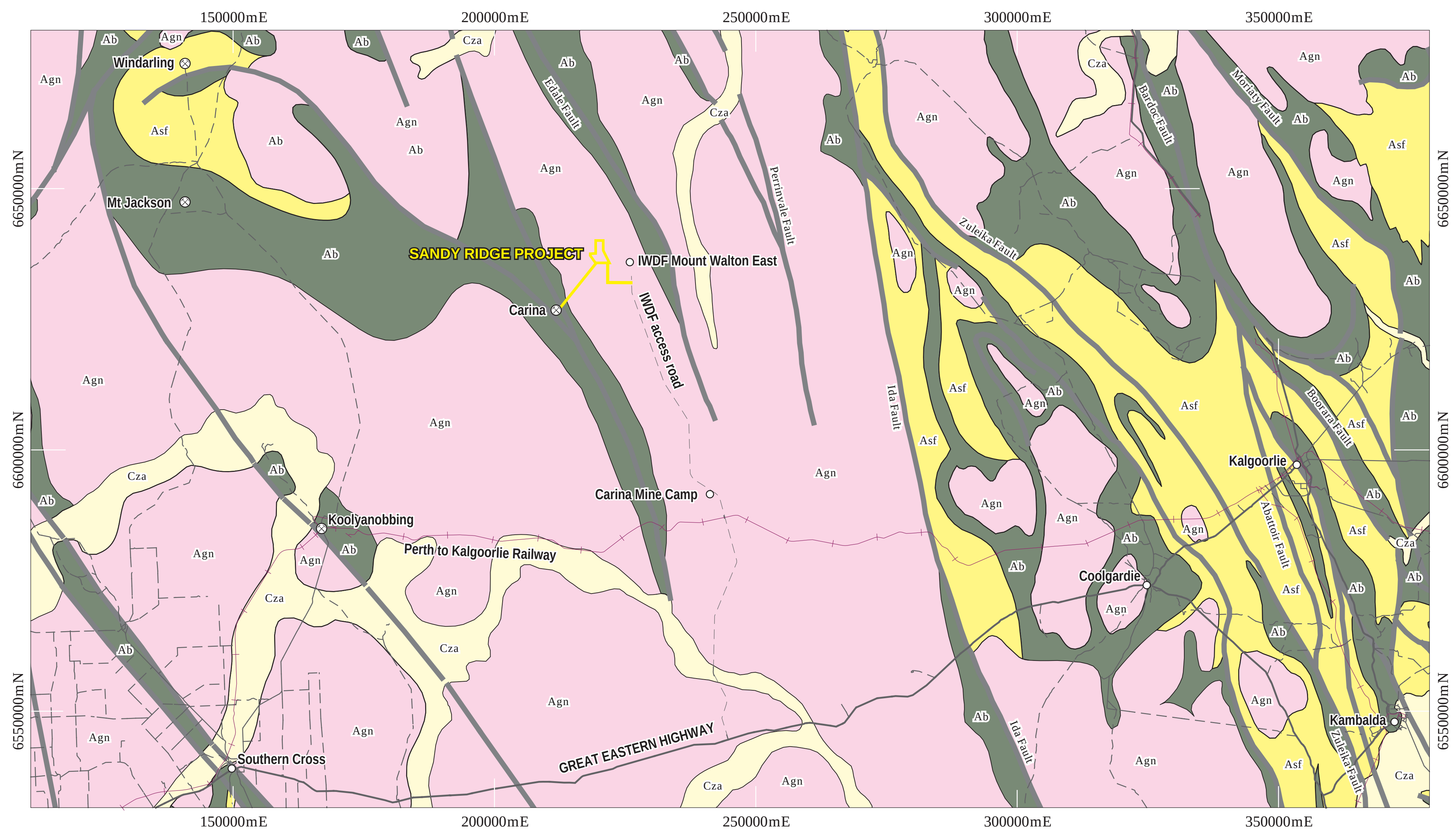
Table 9-6 Drilling history in and around Sandy Ridge

Activity	Drill holes	Metres
IWDF drilling (1995)	53	1,397
IWDF drilling (1995) within E16/440	10	337
IWDF monitoring bore drilling (1995)	2	39
E16/440 resource drilling (2014)	61	1,864
E16/440 resource drilling (2015)	51	1,355
E16/440 bulk sample drilling (2015)	88	2,162
E16/440 monitoring bore drilling (2015)	7	226
TOTAL	**272**	**7,380**

The local geology is well understood due to mineral exploration drilling across the exploration tenement. In geological terms the proposed development envelope is a deeply weathered granitoid terrane that generally comprises four main lithologies. From the surface these are:

- **Colluvial sand and gravel with mottled zone laterite** – this comprises mostly yellow brown quartz sand overlying pisolitic-ironstone gravel and/or nodular red-brown clayey sand (lateritic mottled zone).
- **Silcrete** – comprises kaolinitic clay and silica to form a hard cap over underlying lithologies. This layer is essentially as hard as granite. It has a sharply defined upper surface that undulates quite sharply at times with numerous protrusions; it exhibits peaks and troughs that have amplitudes up to 1 m. The silcrete does not display much fracturing, but some parts near the surface may be disrupted by tree roots. The base of the silcrete generally merges gradationally into the underlying kaolinitic clay profile and as a result the silcrete can be quite variable in terms of overall thickness. The silcrete has most likely been hardened as the result of a secondary chemical process that effectively has re-cemented the kaolinitic clay profile from its upper surface.
- **Kaolinitic clay** – comprises soft white kaolin weathered from pre-existing granitoids. As a result, the clays contain relict quartz phenocrysts. This clay profile may be absent in some areas where silcrete stretches to the granitoid basement, but generally is more than 15 m thick and up to a maximum of nearly 40 m thick. The clay is quite uniformly white with little fracturing and only exhibits minor iron staining in the few fracture zones present.
- **Granitoid basement** – comprises a fine to medium grained light coloured granite containing pegmatite and quartz veins. The basement topography varies widely to less than 5 m from the surface to greater than 45 m below the surface.

Plate 9-17 shows a typical lithological profile through the weathered granite profile (extracted from CRM, 2015). The profile commences with sand/laterite (bottom tray in Plate 9-17) and grades into silcrete, mottled kaolin and white kaolin. Below the white kaolin is a saprock zone, the top of which represents the base of complete oxidation underlain by the fresh granite (CRM, 2016). The formation of the profile is described in Appendix A.4.



Legend:	Ab	Metamorphosed basic and ultrabasic volcanic and intrusive rocks
⊗ Iron Ore Mine	Agn	Granite and Gneiss
Rail	Asf	Metamorphosed sedimentary and acid volcanic rocks
Major Road		
Minor Road	Cza	Alluvial, shoreline, & eolian deposits
Faults		

*Geology: DMP Generalised Geology of WA 1999

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Local Geology

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Figure:

9-8

Plate 9-17 Lithological profile

9.2.10 Earthquakes

A search of Geoscience Australia's Earthquake Database (Geoscience Australia, 2015a) for information on past earthquakes indicates two earthquakes of similar magnitudes have occurred within 25 km of the proposed development envelope:

- 3 March 2014 – magnitude 2.4 west of the Carina Iron Ore Mine, approximately 22 km south west from the Proposal.
- 4 February 2014 – magnitude 2.5 north of the Mount Walton East IWDF, approximately 17.5 km north east from the Proposal.

No earthquakes have occurred at the proposed location of the cells. Australia is located on the Indo-Australian Plate, and there are no plate boundaries on the continent, therefore tectonic plate activity is not experienced in WA. There are no active or dormant volcanoes in WA.

9.2.11 Tectonic plate movement

The proposed development envelope is situated on the Archaean Yilgarn Shield, within the central portion of the eastern section of the Indo-Australian Plate. This eastern section is, in general, moving north-east at around 5.6 cm per year (Hammonds, 2012).

This rate of movement and the location of the proposed development envelope within a seismically quiet portion of a stable shield is very unlikely to cause any significant tectonic activity (uplift, subsidence, or fracturing) in any timeframe relevant to the Proposal. However, if the present movement continues at the same rate, the proposed development envelope could be expected to approach the present position of the seismically active section of New Guinea in about 60 million years (CRM, 2016).

9.2.12 Volcanic activity

No igneous activity has occurred in the region for over 1,000 million years. The Archaean granite that constitutes the bedrock in the proposed development envelope has been dated at around 2700 million years (Nelson, 2002). A Proterozoic age east-west trending dyke intruded the granitic basement about 20 km south of the proposed development envelope. Similar dykes within the Yilgarn Craton have been dated at circa 2,420 million years (Nemchin and Pidgeon, 1998) and at circa 1210 million years (Pidgeon and Nemchin, 2001).

There is no reason to expect that there would be any sub-surface or surface volcanic activity within this part of the stable craton for at least 50 million years (CRM, 2016).

9.2.13 Weathering, erosion and stability

Current weathering and erosion in the area is extremely slow. The present semi-arid climate, with a median annual rainfall of about 250 mm and an annual evaporation rate over 2,000 mm is not conducive to chemical weathering, which is active in humid temperate to tropical climates, but much less active in semi-arid and arid climates (CRM, 2016).

The present surface has not changed for at least the past 2.6 million years (CRM, 2016) except for the addition of wind-blown sand, and possible minor redistribution of lateritic pebbles. The site has a large amount of silcrete and laterite. The presence of these rock types is a good indication that the site lacks erosion.

The proposed development envelope is situated at an elevation of between 460 m and 490 m in an area of low relief. It contains no active stream channels and no known paleo-channels, and is distant from any major drainage system. The near horizontal sandy surface and lack of stream channels results in rain water being absorbed into this surface unit, rather than running off with resulting water erosion. Wind erosion is very limited, as the sandplain is well covered with native vegetation and average wind speeds are low for the majority of the year (refer to Figure 9-5).

It is the combination of a virtually flat plateau, cemented surface layers, and semi-arid conditions that creates the stable geomorphology of the proposed development envelope (CRM, 2016).

9.2.14 Glaciation

There is no evidence that the central portion of the Yilgarn Plateau has been subject to glaciation, even during the most recent Ice Ages of the last 70,000 years, when the only areas in Australia where glaciers were present were the Snowy Mountains and Tasmania (Barrows and Fifield, 2016).

The present north-easterly movement of the Australian continent towards the tropics and away from the South Pole suggests that there is no likelihood of a future glaciation of the area, at least in the next 60 million years (CRM, 2016).

9.2.15 Soils

The proposed development envelope is located within the Norseman (266) soil landscape mapping zone, within the Kalgoorlie Province as defined by Tille (2006). The soils of the Norseman zone are described as calcareous loamy earths, yellow sandy and loamy earths, red loamy earths, red deep sands and salt lake soils.

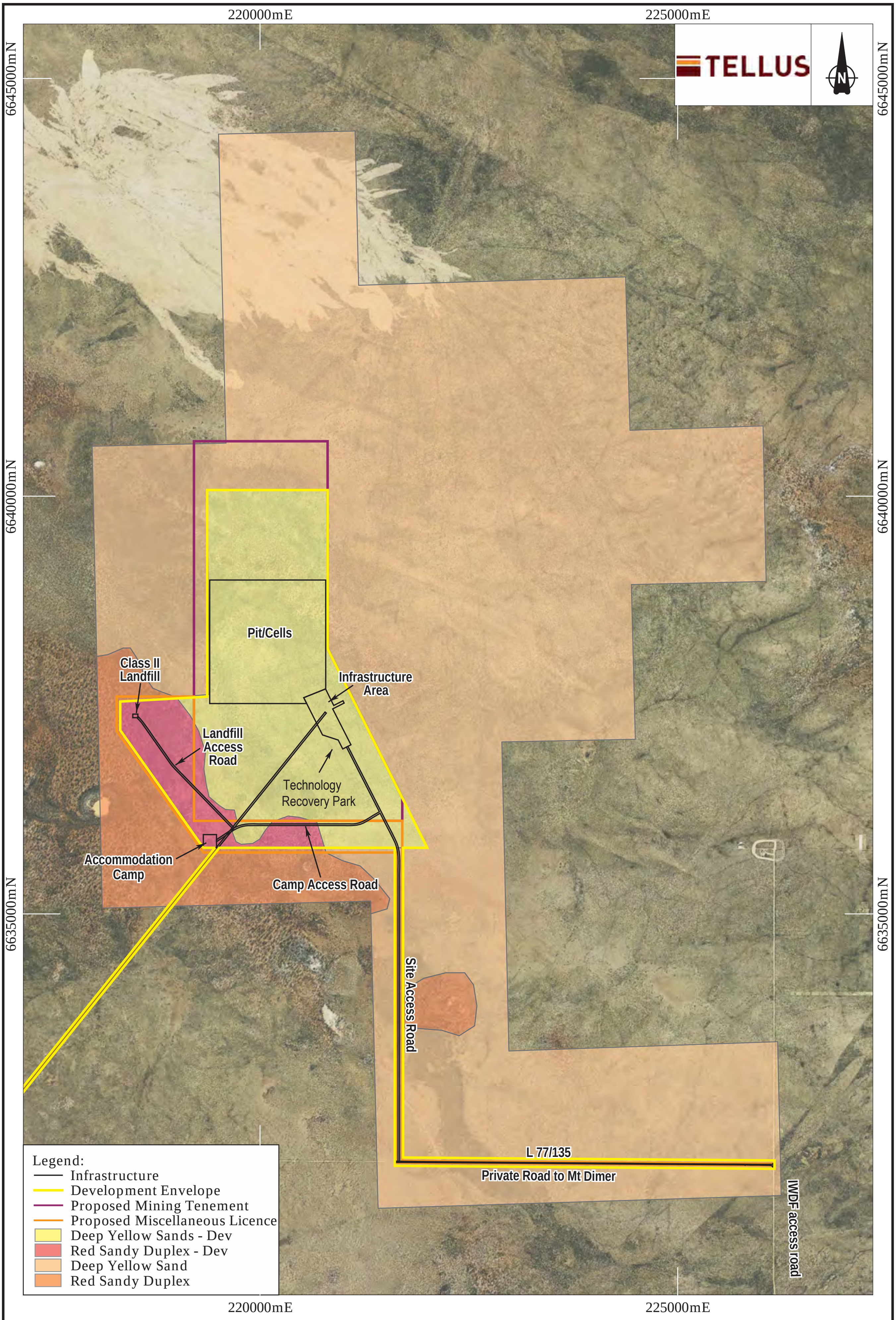
The field assessment identified two soil types within the proposed development envelope; Deep Yellow Sand and Red Sandy Duplexes (refer to Figure 9-9). The Deep Yellow Sand is associated with the higher relief areas of low sandy dune systems of the proposed development envelope. The pH of the Deep Yellow Sand was strongly acidic, with pH ranging from 4.2 to 4.9.

The soil extents within the proposed development envelope are:

- Red Sandy Duplex – 8.26 ha.
- Deep Yellow Sands – 65.8 ha

The field assessment results correlated with the soil landscape mapping (Tille, 2006). The Red Sandy Duplex is associated with the lower-lying areas of the proposed development envelope, potentially broad areas of drainage, and consequently are areas of potential erosion.

The Red Sandy Duplexes were found at shallow depths (<0.3 m BGL) over a tightly packed laterite ferricrete. The pH of the Red Sandy Duplex was neutral at the surface (pH 7.0) to alkaline at depth (pH 8.9). Based on the number of Red Sandy Duplexes samples analysed the average pH was 7.6.



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CAD Ref: g2294_PER_07_05.dgn	Author: C. Dorrington | AE Ref: THO2014-003	**Soils**	**9-9**
Date: November 2016 | Rev: H | A4	Drawn: CAD Resources ~ www.cadresources.com.au Tel: (08) 9246 3242 ~ Fax: (08) 9246 3202	**Public Environmental Review**	

9.3 Terrestrial fauna

This section discusses fauna and fauna habitat within the proposed development envelope. The presence of fauna of conservation significance is also discussed.

9.3.1 Terrestrial fauna habitat

The proposed development envelope is located in the Southern Cross IBRA Subregion. The Southern Cross IBRA Subregion is characterised as a weathered plain comprising gently undulating uplands dissected by broad valleys with bands of low greenstone hills. The subregion is characterised by a diverse eucalypt woodland and low heaths.

Two fauna habitats were recorded within the proposed development envelope. These included open woodland and shrublands as described in Table 9-7 and illustrated in Figure 9-10 and Figure 9-10 b. Fauna species potentially occurring within these habitats are detailed in Appendix A.8.

Table 9-7 Fauna habitats within the proposed development envelope

Broad fauna habitat type	Fauna habitat mapping	Condition
Open woodland	Open eucalypt woodland with an open understorey of shrubs over ephemeral grasses or scattered spinifex on red sandy clay soils.	Very good to excellent condition.
Shrubland	Moderately dense to dense sand plain shrubland varying in height from 0.5–1.8m on yellow sandy soils.	Very good to excellent condition.

Source: Terrestrial Ecosystems (2015)

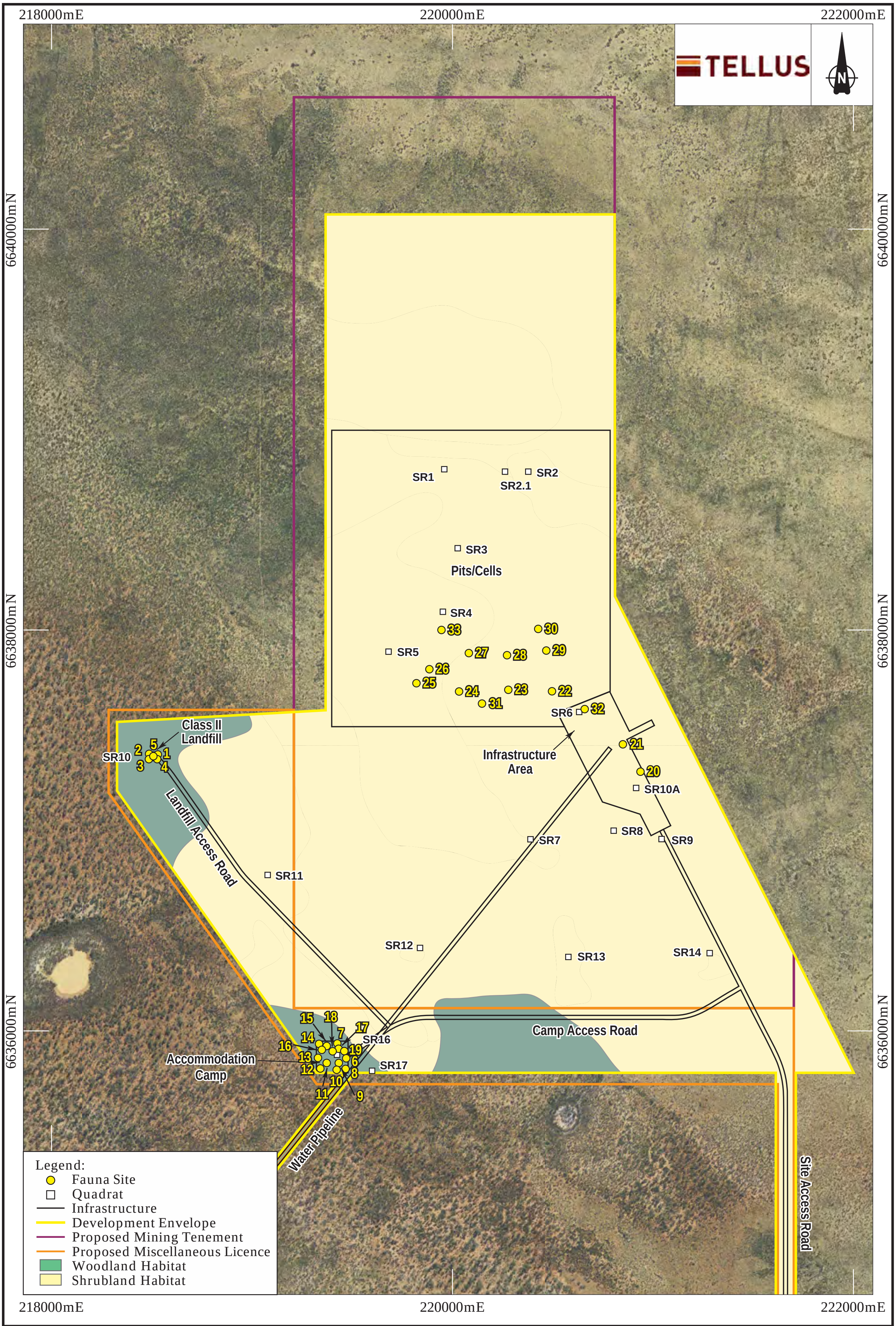
9.3.2 Ecological linkages

Ecological linkages are a series of (both contiguous and non-contiguous) patches of native vegetation which, by virtue of their proximity to each other, act as stepping stones of habitat which facilitate the maintenance of ecological processes and the movement of organisms within, and across, a landscape. The proposed development envelope currently does not provide any important ecological linkages or fauna movement corridors as it is part of a large and relatively undisturbed area.

9.3.3 Vertebrate fauna species of conservation significance

Fourteen fauna species listed under the WC Act and/or EPBC Act or by DPAW have been recorded or are predicted to occur within the proposed development envelope or within the locality (refer to Table 9-8). Evidence of two of these species was recorded within the proposed development envelope during the field surveys. These were Malleefowl (*Leipoa ocellata*) (listed as Vulnerable under the WC Act and the EPBC Act) and Rainbow Bee-eater (*Merops ornatus*) (listed as Migratory under the WC Act and the EPBC Act). These species are discussed further below.

An additional four listed species may possibly occur within the proposed development envelope. These species include sp. 1 Central Long-eared Bat (*Nyctophilus timoriensis*), Western Rosella (Mallee) (*Platycercus icterotis xanthogenys*), Fork-tailed Swift (*Apus pacificus*) and Peregrine Falcon (*Falco peregrinus*). The remaining species are considered unlikely to occur within the proposed development envelope due to a lack of suitable habitat and, therefore, would not be affected by the Proposal.



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Fauna habitats

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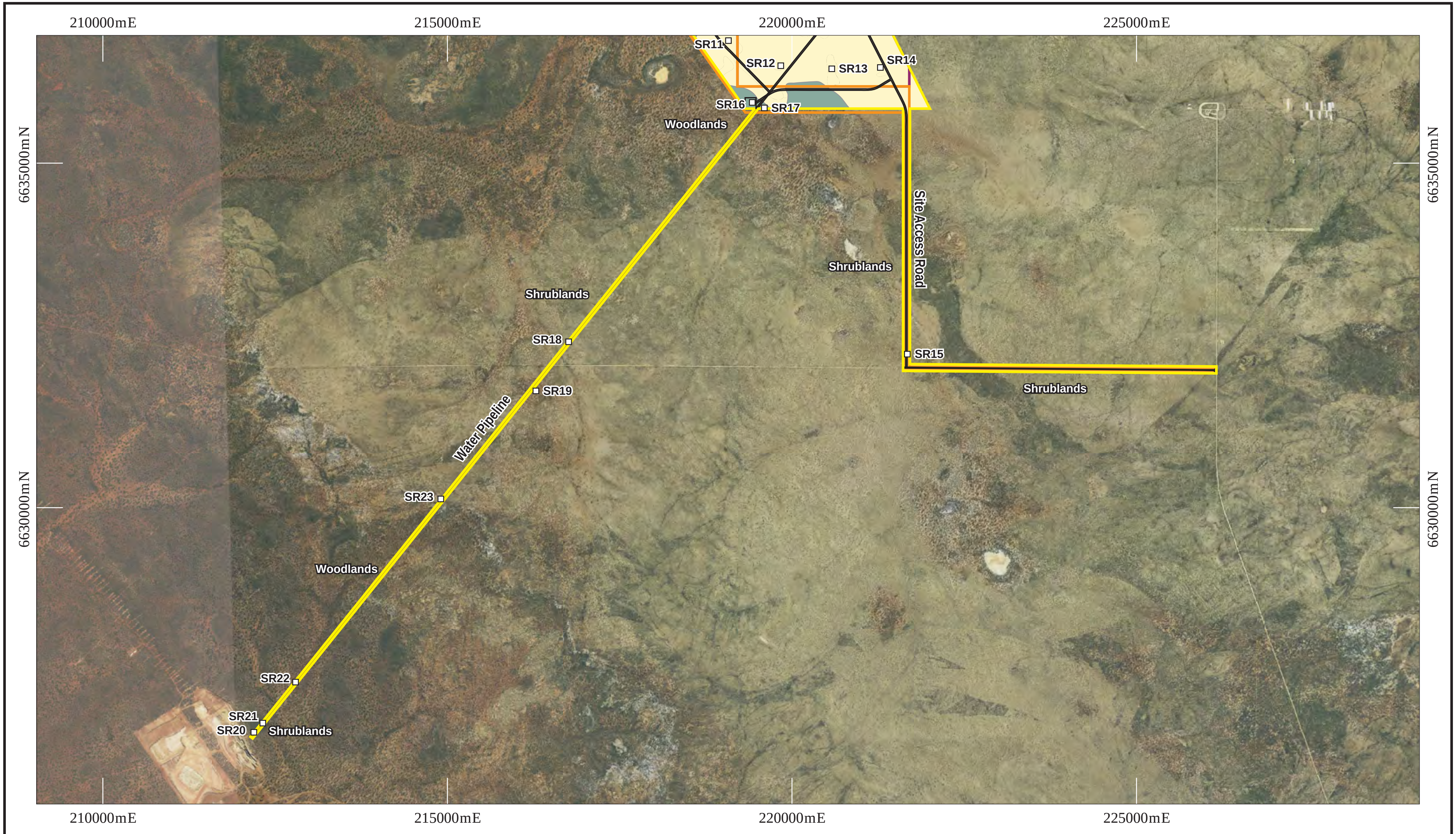
Figure:

9-10a



Legend:
- Quadrat
- Infrastructure
- Development Envelope
- Proposed Mining Tenement
- Proposed Miscellaneous Licence
- Woodland Habitat
- Shrubland Habitat

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Fauna habitats - water pipeline and access road

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Figure:

9-10b

Malleefowl (Leipoa ocellata)

No Malleefowl or active breeding mounds were observed within the proposed development envelope 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 (refer to Plate 9-18).

Five mounds were large (up to 9 m wide, 0.5 m high and 0.3 m deep) and distinctive although not recently used.

Mounds were found where the soils were a gravelly loam, with the mounds themselves being composed largely of lateritic gravel.

Malleefowl are likely to occur in the proposed development envelope only as an occasional visitor. Malleefowl can be expected to return to the proposed development envelope and surrounding areas as a breeding species at a low density when the vegetation has matured. It favours gravelly soils for mound construction and these lie mostly outside the proposed development envelope.

Plate 9-18 Malleefowl mound (very old); little more than a raised patch of gravel

Plate 9-19 Malleefowl mound with well-defined central depression.

Rainbow Bee-eater (Merops ornatus)

Two Rainbow Bee-eaters were observed during the field survey; however, as the nesting period had finished for the season, it was assumed the birds were just passing through. Sandy to sandy loam soils within the proposed development envelope would be suitable breeding habitat for this species, however no recently used burrows were observed. Therefore, Rainbow Bee-eaters may be present when transiting across the proposed development envelope.

Table 9-8 Potentially occurring conservation significant vertebrate fauna species

Species[23]	Conservation status		Habitat	Likelihood of occurrence
	EPBC Act	WA status[24]		
Mammals				
Numbat ***Myrmecobius fasciatus***	Vulnerable	Endangered	Current populations inhabit Jarrah forest, open Eucalypt woodland, *Banksia* woodland and tall closed shrubland. Habitats usually have an abundance of termites in the soil, hollow logs and branches for shelter (DEC, 2012).	Unlikely. Not recently recorded in the vicinity of the proposed development envelope.
Chuditch ***Dasyurus geoffroii***	Vulnerable	Vulnerable	Chuditch are known to have occupied a wide range of habitats from woodlands, dry sclerophyll (leafy) forests, riparian vegetation, beaches and deserts. Riparian vegetation appears to support higher densities of Chuditch, possibly because food supply is better or more reliable and better cover is offered by dense vegetation. The estimated home range of a male Chuditch is over 15 km^2 whilst that for females is 3–4 km^2 (Sorena and Soderquist, 1995).	Unlikely. The proposed development envelope is outside the normal distribution of this species. The species has not recently been recorded in the vicinity of the proposed development envelope.
Central Long-eared Bat ***Nyctophilus(timoriensis)*** **sp. 1**	-	Priority Fauna (P4)	The proposed development envelope is on the north-western boundary of its known distribution. It roosts in tree cavities, foliage and under loose bark (Terrestrial Ecosystems, 2015).	Possible. Within known distribution and suitable habitat present.
Western Brush Wallaby ***Macropus irma***	-	Priority Fauna (P4)	The species optimum habitat is open forest or woodland, particularly favouring open, seasonally wet flats with low grasses and open scrubby thickets. It is also found in some areas of mallee and heathland, and is uncommon in Karri forest (DEC, 2012).	Unlikely. Not recorded in recent surveys.
Western Mouse ***Pseudomys occidentalis***	-	Priority Fauna (P4)	Tall shrub land with mallee eucalypts and a heath understorey on a substrate of gravelly loam (Kitchener and Chapman, 1977).	Unlikely. Not recorded in recent surveys.

[23] *Species listed in Terrestrial Ecosystems (2015) which have since been deleted from the Wildlife Conservation (Specially Protection Fauna) Notice 2015 have been excluded from this table.*
[24] *Priority species are listed by DPAW. Endangered, vulnerable, migratory and specially protected fauna listed under the WC Act 1950 (WA).*

Species[23]	Conservation status		Habitat	Likelihood of occurrence
	EPBC Act	WA status[24]		
Quenda ***Isoodon obesulus fusciventer***	-	Priority Fauna (P4)	Dense scrubby, often swampy, vegetation with dense cover up to one metre high, often feeds in adjacent forest and woodland that is burnt on a regular basis and in areas of pasture and cropland lying close to dense cover. Populations inhabiting jarrah and Wandoo forests are usually associated with watercourses. Quendas can thrive in more open habitat subject to exotic predator control (DEC, 2012).	Unlikely.
Reptiles				
Southern Death Adder ***Acanthophis antareticus***	-	Priority Fauna (P3)	The Southern Death Adder is a very cryptic snake that is found from the Darling Range, central Wheatbelt and from Esperance across the Nullarbor Plain to the South Australian border (Cogger, 2014). It is rarely caught in fauna surveys and only opportunistically encountered on roads and in undisturbed bushland.	Unlikely. Rarely encountered in the Southern Cross IBRA subregion.
Birds				
Carnaby's Black Cockatoo ***Calyptorhynchus latirostris***	Endangered	Endangered	Forests, woodlands, heathlands, farms; feeds on *Banksia*, *Hakea* and Marri. Carnaby's Black-Cockatoo has specific nesting site requirements. Nests are mostly in smoothed-barked eucalypts with the nest hollows ranging from 2.5–12 m above the ground, an entrance from 23–30 cm diameter and a depth of 0.1–2.5 m (Johnstone and Storr, 1998).	Unlikely. The proposed development envelope is outside the normal distribution of this species. The species has not been recently recorded in the vicinity.
Malleefowl ***Leipoa ocellata***	Vulnerable	Vulnerable	Mainly scrubs and thickets of mallee *Eucalyptus* sp., boree *Melaleuca lanceolata* and bowgada *Acacia linophylla*, also dense litter forming shrublands (DEC, 2012).	Likely. Potentially in the general area and may be an occasional visitor to the proposed development envelope. No active mounds are present within the proposed development envelope; therefore, it is currently unlikely to use the proposed development

Species[23]	Conservation status EPBC Act	WA status[24]	Habitat	Likelihood of occurrence
				envelope for nesting habitat. Evidence of this species was recorded within the proposed development envelope during the field surveys.
Western Rosella (mallee) Platycercus icterotis xanthogenys		Priority Fauna (P4)	The mallee form of the Western Rosella is found mostly in Eucalypt and *Casuarina* woodland and shrublands, especially Wandoo, Flooded Gums and Salmon Gums (Terrestrial Ecosystems, 2015).	Possible. This species could potentially occur in the eucalypt woodland, however the proposed development envelope is north of where it was previously recorded (McKenzie and Rolfe, 1995). Has not been recorded in recent surveys (BCE, 2016).
Fork-tailed Swift ***Apus pacificus***	Migratory	Schedule 5 (Migratory)	Low to very high airspace over varied habitat from rainforest to semi-desert (Morcombe, 2003).	Possible.
Rainbow Bee-eater ***Merops ornatus***	Migratory	Schedule 5 (Migratory)	Open country, woodlands, open forest, semi-arid scrub, grasslands, clearings in heavier forest, farmlands (Morcombe, 2003). Breeds underground in areas of suitable soft soil firm enough to support tunnel building.	Likely. This species could potentially occur within the proposed development envelope. This species could potentially breed in sandy areas if conditions were suitable. Evidence of this species was recorded within the proposed development envelope during the field surveys.
Peregrine Falcon ***Falco peregrinus***	-	Schedule 7 (Other specially	Diverse habitat from rainforest to arid shrublands, from coastal heath to alpine (Morcombe, 2003). Mainly about cliffs along coasts, rivers and ranges and about wooded watercourses and lakes (Johnstone and Storr, 1998). The species utilises ledges, cliff	Possible.

Species[23]	Conservation status		Habitat	Likelihood of occurrence
	EPBC Act	WA status[24]		
		protected fauna)	faces and large hollows/broken spouts of trees for nesting. It would also occasionally use the abandoned nests of other birds of prey.	
Hooded Plover ***Charadrius rubricollis***	Marine (as *Thinornis rubricollis*)	Priority Fauna (P4)	This species frequents the margins and shallows of salt lakes, and also along coastal beaches, where it forages for invertebrates (Johnstone and Storr, 1998).	Unlikely. Lack of suitable habitat.

9.4 Inland waters environmental quality

This section describes the hydrology and hydrogeology of the proposed development envelope.

9.4.1 Hydrology

No channels or creeks occur in the proposed development envelope (Rockwater, 2015). There are no major flow paths in the area of the proposed cells, and surface water runoff would only be generated from very infrequent high rainfall events (Rockwater, 2015). These flows would be from small local catchments which drain residual runoff after infiltration losses, to low–lying depressions. Generally surface water would only be retained for short periods in the depressions due to continual infiltration. In addition, there would be evaporation of water in clay pans, this would typically begin three days after a major rainfall event once clouds have lifted. Water may drain into the proposed cell area from the north and east because it has a slighter higher elevation but only in the event of infrequent, very high rainfall events.

Based on rainfall analysis the likely peak run-off for rainfall events between 1 in 2 and 1 in 2000 years ARI are listed in Table 9-9.

Table 9-9 Total rainfall including probable maximum precipitation

Duration (Hours)	ARI / total rainfall (mm)									
	2	5	10	20	50	100	200	500	1000	2000
24	40	57	70	87	113	136	155	180	201	222
48	47	68	83	104	135	163	186	216	241	266
72	50	72	89	111	146	176	200	232	258	285

In order to compare estimated total rainfall levels for a range of estimated ARI, the maximum recorded rainfalls from other weather stations in the vicinity of the proposed development envelope were reviewed.

The two largest recorded total rainfalls over 72 hours occurred in 1948 and 1995, at Menzies and Ora Banda, both of which are within 115 km of the proposed development envelope. The rainfall recorded was 211.6 mm and 280.8 mm at Menzies, and 254.0 mm and 189.8 mm at Ora Banda. The information in Table 9-9 indicates that the 1948 and 1995 rainfall events were extreme events. The volumes of rainfall recorded at the two locations equate to a 1 in 2000 ARI.

The total rainfall for a range of ARI and the maximum recorded rainfalls were compared against infiltration losses. Infiltration rates for sandy soils can be up to 720 mm/day and are typically about 500 mm/day for sandy, loamy soil.

The proposed development envelope has predominantly sandy soil; with some small clay pans where infiltration rates could be between 24 and 120 mm/day. During the highest recorded rainfalls, sandy loam soil should experience an infiltration loss within 12 hours, or soon after. This means the likelihood of widespread water pooling on the surface within the proposed development envelope is rare.

9.4.2 Surface water catchments and peak flows

Fourteen catchments were identified in the proposed development envelope and their flow paths are shown in Figure 9-11. If water does not infiltrate over the flow path, it would pool in a depression until it infiltrates or evaporates. Five depressions were identified in the vicinity of the proposed development envelope (refer to Figure 9-11). A further two depression occurred outside of the proposed development envelope.

The estimated peak flows over the access road range from approximately 10 m^3/s to 35 m^3/s for the 100 year ARI event and 40 m^3/s to 130 m^3/s for the probable maximum flood (2,000 year event). It must be noted the access road lacks vegetation which is likely to increase the speed of surface water flows.

Peak flows would typically occur approximately 20 minutes after the start of a rainfall event, and flow depth and widths would be the same speed with or without infiltration, but flow depths and widths would reduce by the end of a rainfall event.

Flow durations would be short. For example, peak flows in the vicinity of the proposed cell and infrastructure area range from approximately 1.6 m^3/s to 5.5 m^3/s and for the probable maximum flood 2,000 year event from 7 m^3/s to 20 m^3/s.

If surface water flows are generated within the proposed development envelope, they would likely follow the natural topography until they evaporate (within 12 hours) or infiltrate (at a rate of up to 500 mm/day).

The area and length of the 14 catchments for typical ARI up to the 100 year event and probable maximum flood (1 in 2000 years) are summarised in Table 9-10.

The table shows that the largest catchments (RA, RB, RD and RC and RD) are the largest of the 14 catchments. The remainder of catchments (A to K) are all under 1 km^2. The contributing catchments at the Sandy Ridge site are E, F, G and H. Cross sections for these catchments and the corresponding flows base don a 100 year ARI are shown in Table 9-11.

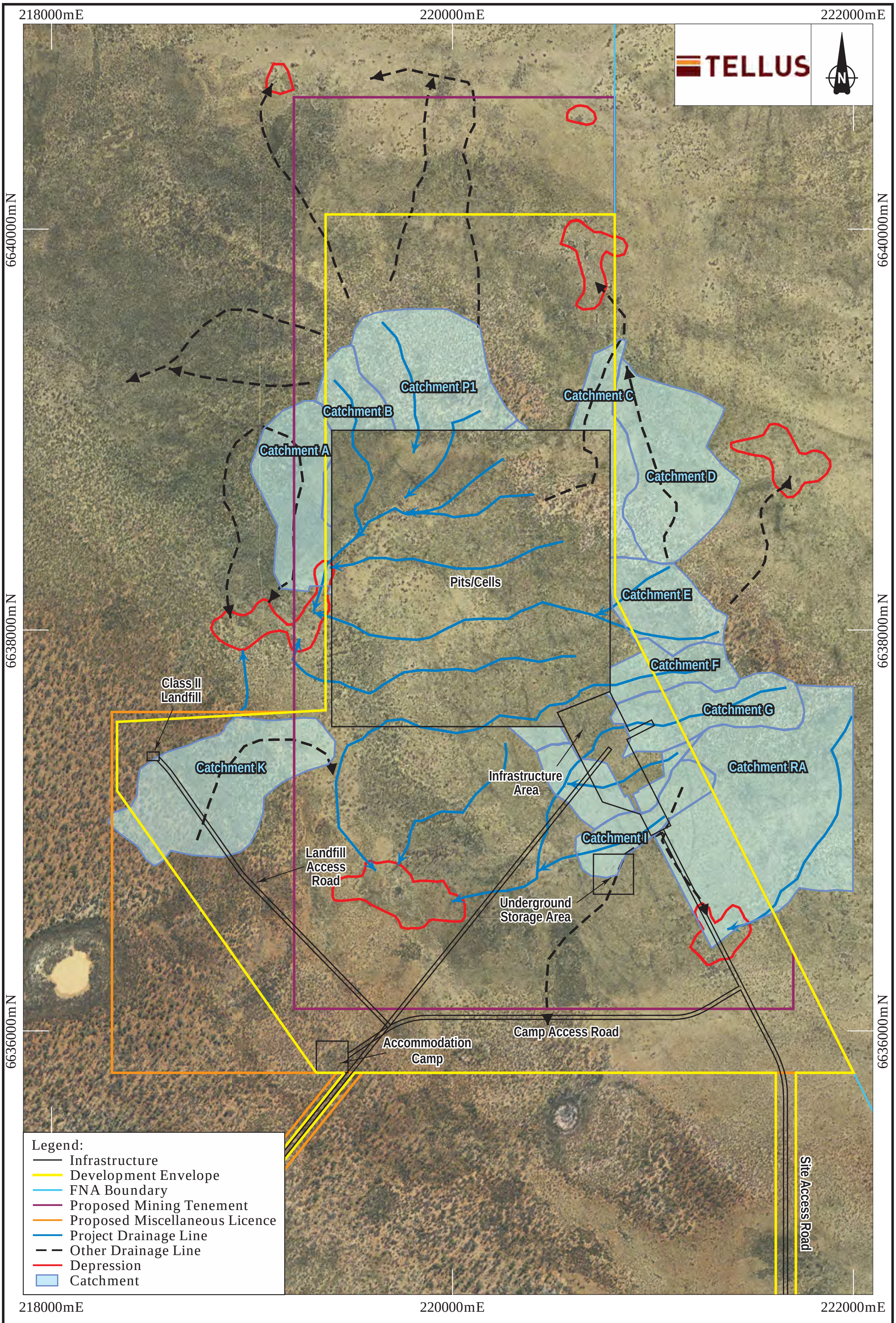
Table 9-10 Characteristics of catchments

Catchment	Area (km^2)	Length (km)
A	0.32	0.88
B	0.15	0.73
C	0.31	0.91
D	0.39	0.90
E	0.24	0.65
F	0.26	1.18
G	0.11	0.96
H	0.11	0.44
I	0.23	0.63
J	0.07	0.41
K	0.48	1.03
P1	0.41	0.75
P2	0.07	0.18
P3	0.50	1.06
RA	1.48	1.58
RB	2.80	2.37
RC	13.85	6.70
RD	15.22	5.65

Table 9-11 Contributing catchments in peak flows

Cross section	Contributing catchments	100 year ARI flows (m^3/s)
XS1	E	3.93
XS2	0.5 * F	1.63
XS3	F	3.25
XS4	G	1.84
XS5	H	2.56

The potential impacts of the above peak flows under a 1 in 100 year rainfall event are discussed in Section 10.5.3.



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MGA94 (Zone 51)
CAD Ref: g2294_PER_07_08.dgn
Date: November 2016 | Rev: H | A4

Aurora environmental

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Catchment surface water flows

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Figure:

9-11

9.4.3 Hydrogeology (desktop review)

The hydrogeology of the proposed development envelope is characterised as weathered granite rock with minor groundwater resources (Kern, 1994). With the exception of groundwater bores for monitoring purposes at the IWDF (approximately 5.5 km east of the proposed development envelope) and water supply bores at the Mount Dimer Gold Mine, greater than 23 km from the proposed development envelope, there are no other known registered users of groundwater in the vicinity of the Proposal.

A groundwater investigation of the Mount Walton north-east area in 1988 (excluding drilling, but including the area in which the IWDF and the proposed Sandy Ridge site are situated) considered both areas to be suitable for the permanent isolation of hazardous wastes (Hirschberg, 1988). The early investigations for the siting of the IWDF indicated a low likelihood of aquifers. Further investigation and subsequent drilling confirmed this because no aquifers were intersected.

Previous drilling investigations in the region (Soil & Rock Engineering, 1989 and ATA Environmental, 1995) comprising 21 drill holes did not detect a groundwater aquifer (see Figure 9-12 for locations of drill holes). Permeability tests conducted on four of the 21 holes gave approximate in situ soil permeability values for the weathered granite ranging from 2.5 x 10^{-8} m/s to 3.2 x 10^{-7} m/s. These values mean the kaolin is not permeable and is very dry.

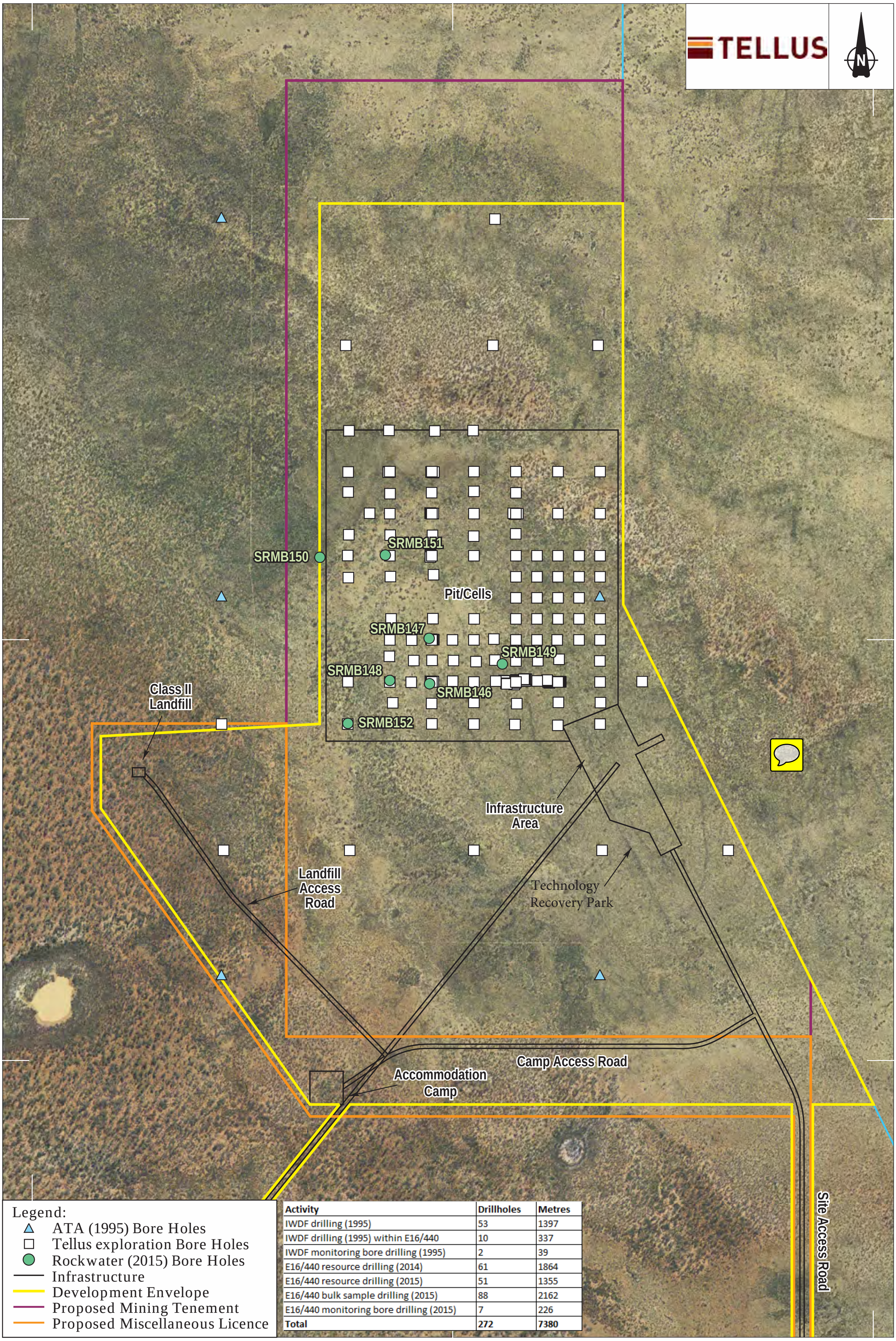
9.4.4 Hydrogeology (field investigation)

On 14 and 15 April 2015, seven investigation groundwater bores were drilled and constructed within the proposed development envelope (refer to Figure 9-12). The depth of the holes ranged from 21 m to 49 m BGL with drilling ceasing on refusal in weathered or fresh granite. The methodology and construction details of each bore are provided in Appendix A.11.

All seven holes intersected typical granite weathering profiles. This comprises 2–3 m of surficial aeolian sand overlying up to 8 m of silcreted clay and/or laterite, then mottled and pallid zone clays/very deeply to completely weathered granite; with slightly weathered to fresh granite and from 26–31 m BGL in borehole SRMB146. Minor cavities were observed in the silcrete, clay, kaolinite and weathered granite.

No aquifer was intersected during the investigation. Salinity of the moisture abstracted within damp soils ranged between 6032 and 6565 mg/L TDS. This result means the water content within the soil is moderately saline. Permeability (hydraulic conductivity) testing was undertaken on all bores and the results are listed in Table 9-12.

The low/dry permeability show that the water-bearing zones contain small quantities of water and do not constitute an aquifer.



Activity	Drillholes	Metres
IWDF drilling (1995)	53	1397
IWDF drilling (1995) within E16/440	10	337
IWDF monitoring bore drilling (1995)	2	39
E16/440 resource drilling (2014)	61	1864
E16/440 resource drilling (2015)	51	1355
E16/440 bulk sample drilling (2015)	88	2162
E16/440 monitoring bore drilling (2015)	7	226
Total	**272**	**7380**

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Figure:
9-12

Table 9-12 Results of permeability testing

Bore ID	Test number	Dry permeability (meters/day)	Dry permeability (meters/second)	Lithology of screened interval
SRMB146	1	0.14	1.62×10^{-6}	Kaolinite and deeply weathered granite.
	2	0.12	1.36×10^{-6}	
SRMB147	1	0.93	1.08×10^{-5}	Kaolinite (saprolite).
SRMB148	1	0.99	1.15×10^{-5}	Kaolinite (weathered granite).
SRMB149	1	0.39	4.51×10^{-6}	Weathered granite.
	2	0.22	2.55×10^{-6}	
SRMB150	1	0.03	3.47×10^{-7}	Weathered and fresh granite.
	2	0.02	2.31×10^{-7}	
SRMB151	1	0.33	3.82×10^{-6}	Moderately to slightly weathered granite.
SRMB152	1	0.19	2.20×10^{-6}	Weathered granite.
	2	0.18	2.08×10^{-6}	

Source: Rockwater Pty Ltd (2015a).

9.4.5 Conceptual hydrogeological information

Conceptual cross sections were prepared for the proposed cells (refer to Figure 9-13 and Figure 9-14). Drilling data shows a granite weathering profile consisting of the following hydrogeological units, which are described from the surface to depth:

- Typically, 2–3 m thick surficial aeolian yellow sand.
- Silcreted clay and/or laterite, approximately 8 m thick.
- Mottled and pallid zone clays/weathered granite (this is the kaolin resource) variable in thickness, but typically around 13 m thick.
- Slightly weathered to fresh granite at a depth of 31–36 m.

The following evidence suggests the absence of a groundwater aquifer within the granite weathering profile proposed to host waste cells:

- No groundwater aquifer has been intersected during the targeted groundwater investigation (Rockwater, 2015).
- No groundwater aquifer has been intersected during exploration drilling. This included 216 holes with depths ranging from 12.0–47.5 m BGL across the proposed development envelope as shown on Figure 9-12.
- Very small quantities of groundwater were airlifted from bores SRMB150 (0.03 L/s) and SRMB152 (<0.01 L/s). The low airlift yield and low permeability show that the water-bearing zones containing the groundwater do not constitute an aquifer (Rockwater, 2015). Water may exist in some pores within the weathered granite profile, but may not be present in all pores nor are all pores connected as is generally the case for a saturated aquifer. A possible explanation for the formation of these moist areas is suggested by CyMod (2016). If the silcrete is absent or more permeable (i.e. vuggy – containing macropores for preferential flow), and an extreme rainfall event occurs, water may infiltrate through macropores into

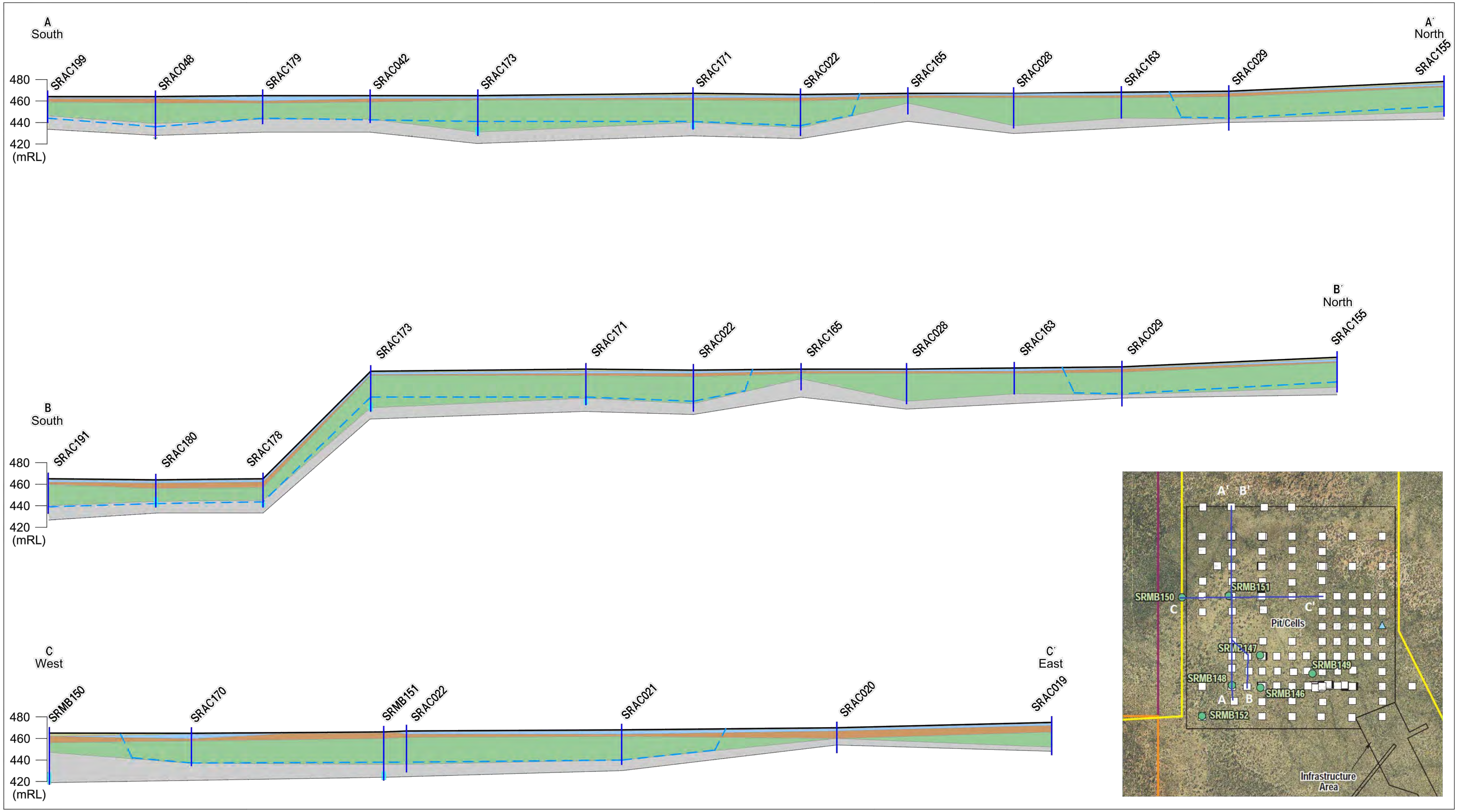
the weathered granite profile to form a damp to saturated zone lying on top of the fresh granite.

- Analysis of resource samples collected during mining exploration activities indicate that for weathered granite deeper than 6m BGL, moisture content is typically between 10% and 12% by weight. This suggests the soil is very dry, the area has limited recharge, the depth to the water table is inferred to be well below the weathered granite, and the material is free draining (i.e. water flows vertically under a unit gradient due to gravity) (CyMod, 2016).
- Since monitoring began in 1995, no groundwater has been detected in monitoring bores at the IWDF. The bores vary in depths of between 24 m and 41 m BGL, (Department of Finance, 2014).

Evidence shows absence of a groundwater aquifer in the weathered granite profile. The absence of a water table in the weathered kaolinised granite on top of the fresh granite suggests any deep water infiltration would subsequently migrate into very low permeability fresh granite and water stored in the fresh granite is to likely to form localised fractured rock aquifers. Hydraulic conductivity of fresh granite is typically in the range of $1x10^{-7}$ to $1x10^{-12}$ m/s, with a porosity of 0.1–1% (Cook, 2003 and CyMod, 2016).

There is no evidence of a shallow groundwater table (i.e. in soils above the silcrete and kaolin). This is expected given the climatic conditions experienced at the site; annual evaporation rate is greater than 2400 mm (BoM, 2015b) which far exceeds the average annual rainfall amount (250 mm). Under these conditions the sporadic rainfall events (which may be temporary but of high intensity) result in local runoff, and some infiltration of rainfall into the thin aeolian surface sand.

However, during subsequent dry periods, evaporation and evapotranspiration acts to remove this rainfall infiltration from the top few metres of soil, which results in little if any net recharge. In the absence of regular recharge, a groundwater table has not formed above the silcrete and kaolin.



Legend:
- Borehole
- Bottom of Kaolin Resource
- Clayey Sand
- Laterite
- Silcrete
- Kaolinised Granite
- Saprock
- Moist

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Sandy Ridge Facility
Interpreted hydrogeological cross section
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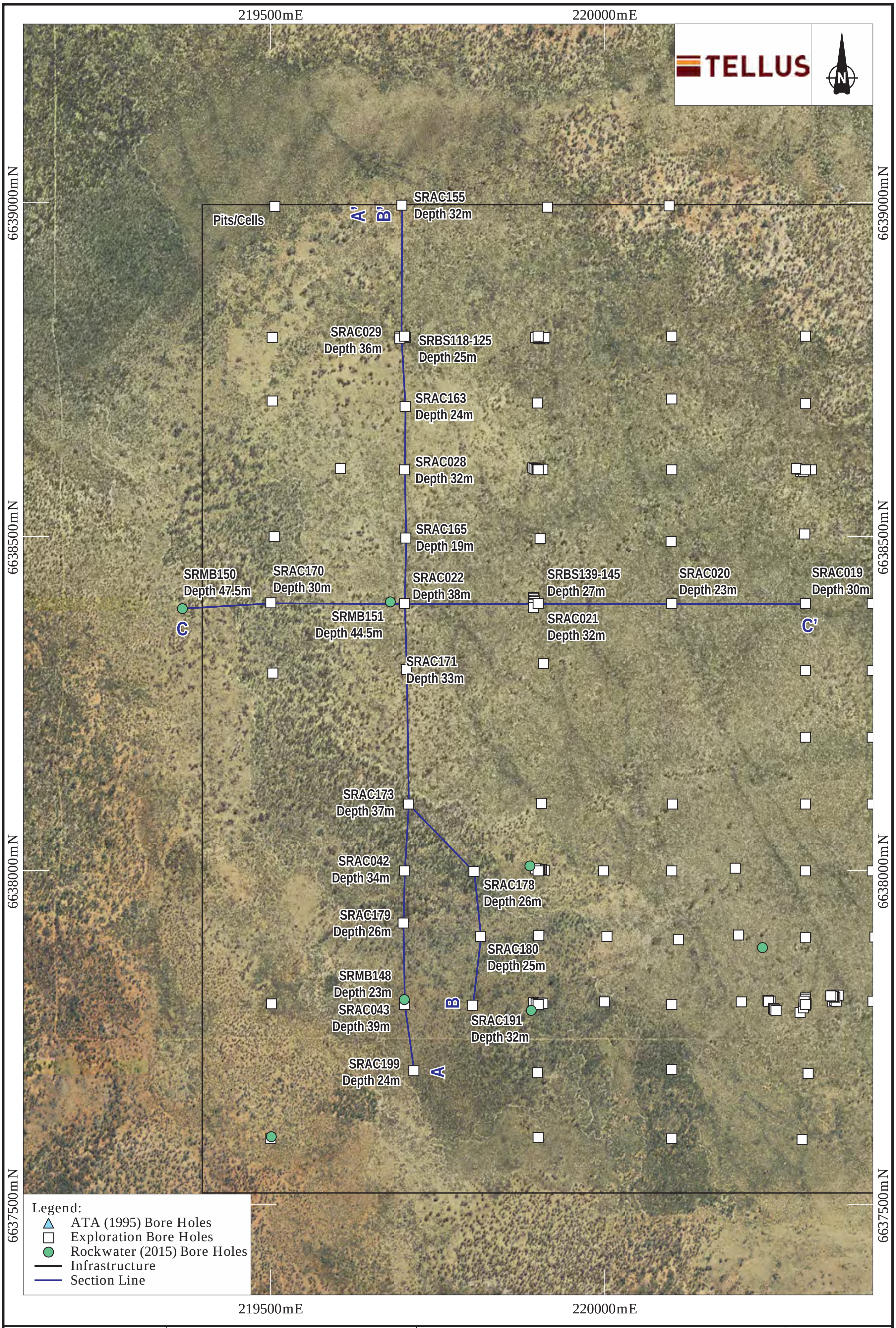
Figure:
9-13



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Interpreted hydrogeological cross section plan view

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Figure:

9-14

9.5 Human health

A desktop assessment of the radionuclides and metals likely to be present in the geology of the proposed development envelope was undertaken in February 2016 (refer to Appendix A.6). Regional radiometrics shows a low background of radiation present in the area. The geology in the area is considered unlikely to produce significant accumulations of uranium or thorium with potassium being the dominant radioactive species. The nearest uranium accumulations identified within the WA Department of Mines mineral occurrence database are calcrete uranium occurrences that form in saline paleochannels and playa lake sediments. The nearest is low level mineralisation, approximately 80 km away at Lake Eva.

There is no evidence of significant paleochannel development in the Sandy Ridge area.

There are no significant thorium accumulations in the region. Regional sampling of the granite shows the uranium content to be consistently at or below 11 ppm. This is considered too low to contribute to any significant secondary surficial uranium enrichment.

Naturally occurring radiation levels within the Proposal area are low (refer to Appendix A.6 for more detail).

9.6 Heritage

There are no known records of heritage items (Aboriginal or European) within or in close proximity to the proposed development envelope as confirmed via online database searches (WA Department of Aboriginal Affairs Site Register, State Heritage Register [inHerit], World Heritage Register, National Heritage Register, Commonwealth Heritage Register and the Australian Heritage Database). In addition, a search of the Land, Approvals and Native Title Unit indicated there are no registered native title claims over the proposed development envelope (Government of Western Australia, 2015).

Field surveys did not record any heritage items (registered or previously unrecorded) or ethnographic values within the proposed development envelope. The field surveys were conducted in consultation with representatives of the Kapam Native Title Group, Kelamaia Kabu(d)n and Widji Group.

9.7 Amenity

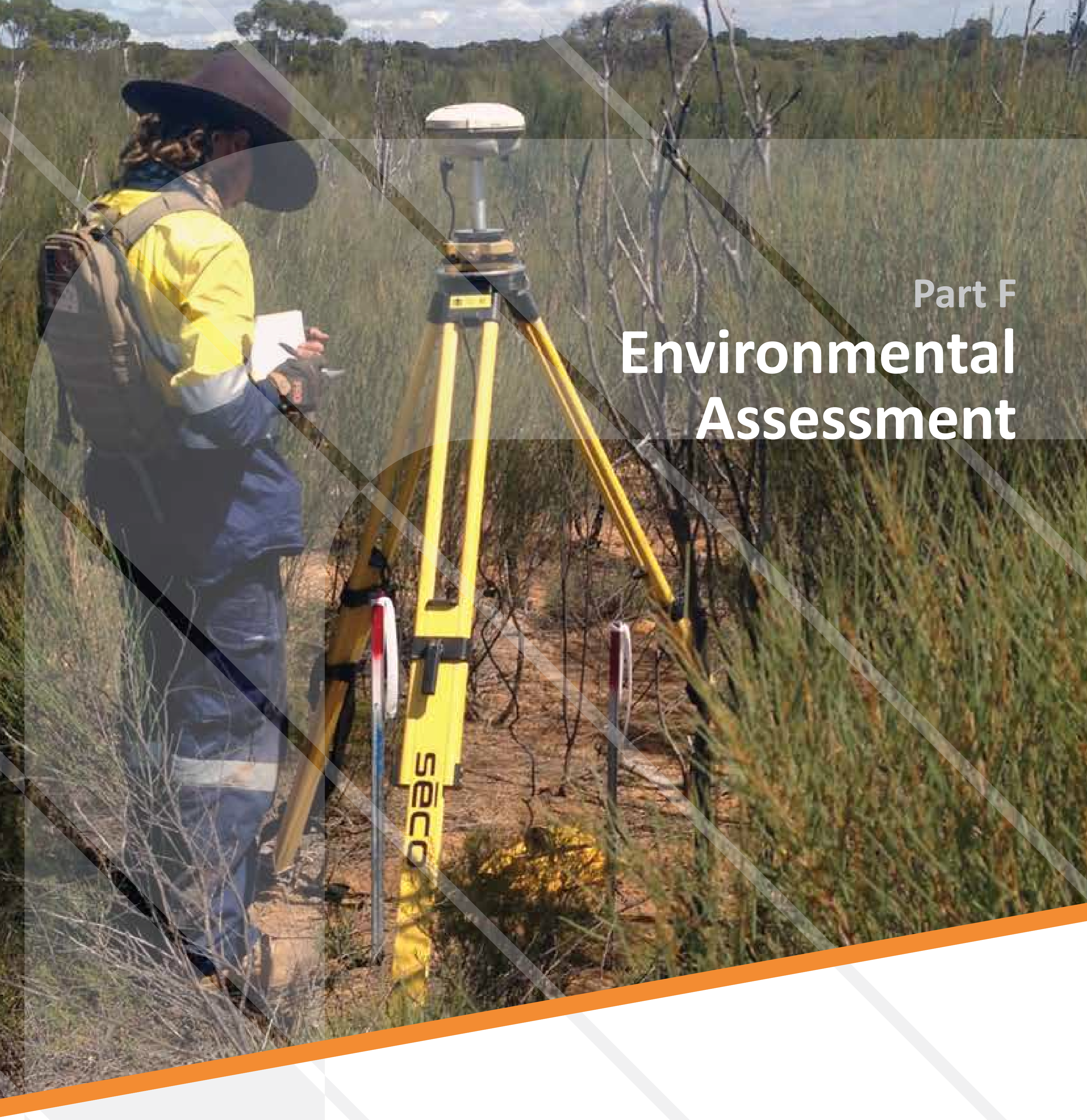
As discussed in Section 9.2.6, the land within the proposed development envelope is currently vacant and undisturbed Crown Land. The water pipeline route would traverse a portion of the former Jaurdi Pastoral Lease, managed by DPAW.

Land use in the vicinity of the proposed development envelope includes vacant and undisturbed Crown Land in addition to the Mount Walton East IWDF which is located approximately 6 km to the east of the proposed development envelope. There are several DPAW managed lands located within the vicinity of the proposed development envelope. These are:

- The Mount Manning Range Nature Reserve, located approximately 9.8 km to the northwest.

- The Mount Manning – Helena and Aurora Ranges Conservation Park, located approximately 19.8 km to the west.
- The Boorabbin National Park, located approximately 100 km to the south.

The location of the proposed development envelope is remote. The nearest permanent residents are tourists staying at the Jaurdi Homestead (approximately 51 km away) and residents of the Carina Iron Ore Mine Accommodation Village (approximately 52 km away). Residents at the Carina Iron Ore Mine Accommodation Village are only present while the mine is operational.



Part F
Environmental Assessment

10 ASSESSMENT OF KEY ENVIRONMENTAL FACTORS

10.1 Overview

The environmental assessment for the Sandy Ridge Proposal has:

(i) Completed a robust environmental impact assessment was carried out in accordance with applicable environmental laws, standards and guidelines.

(ii) Identified a number of potential benefits which include:

a. Creating long-term job opportunities (25 plus years) for local and regional communities.

b. Providing a solution to the inappropriate management and storage of Class V intractable wastes.

c. Opportunities for future recovery and re-use of certain waste streams, e.g. spent pot line residues can be recycled in the aluminium industry.

(iii) Not identified any significant adverse environmental, social or economic impacts arising from the Proposal.

(iv) Outlined, at a high level, necessary environmental mitigation measures which the proponent proposes to implement in order to either avoid or reduce any identified potential negative impacts to an acceptable and manageable level.

A summary of the potental enviornmental impacts and precidcted outcomes of the environmental assessment is presented in Table 10-1.

Table 10-1 Summary of potential environmental impacts and predicted outcomes

Environmental factor	EPA objective	Existing environment	Potential sources of impacts	Environmental management	Predicted outcome
Biophysical					
Flora and Vegetation	To maintain representation, diversity, viability and ecological function at the species, population and community level.	• Coolgardie IBRA Bioregion which covers the interzone between mulga and spinifex country and eucalypt environments over an area of 12,912,204 ha. • Southern Cross IBRA subregion of which approximately 5,773,838 ha of the current extent of pre-European vegetation remains. • Four vegetation associations were identified in the proposed development envelope: o (437) Shrublands; mixed acacia thicket on sandplain. o (141) Medium woodland York gum, salmon gum and gimlet. o (538) *Eucalyptus* open woodland/*Triodia* open hummock grassland. o (435) *Acacia* sparse shrubland/*Cryptandra* mixed sparse heath. • No Threatened, or Endangered, or Priority Ecological Communities were identified in the proposed development envelope. • No Threatened, or Endangered flora was identified in the proposed development envelope. • Priority species were identified in the proposed development envelope; *Calytrix creswellii* (Priority 3), *Lepidosperma lyonsii* (Priority 3) and an undescribed Lepidosperma sp.	• Clearing of 276.05 ha of native vegetation. • Potential for fire and loss of vegetation. • Changed hydrology (quality and quantity of surface water) and effects on downstream vegetation. • Indirect impacts from dust. • Indirect impacts from uptake of saline water from dust suppression. • Introduction and spread of weeds that compete with native vegetation. • Indirect impacts from radiation exposure.	• The proponent would develop and implement a Construction Environmental Management Plan (CEMP) which outlines management and mitigation measures to address potential impacts to flora and vegetation values. A list of measures to be included is provided in Section 10.2.4. • Implement fire prevention and management measures to be included in a site specific Emergency Response Management Plan (ERMP). The conceptual ERMP (flowchart) is contained in Appendix A.22. • Rehabilitation of disturbed areas in accordance with the Mine Closure Plan (Appendix A.19) and Waste Facility Closure and Decommissioning Plan (Appendix A.18).	• The Proposal would clear a maximum (worst case) of 276.05 ha of native vegetation. The actual area of clearing however is likely to be less than this area once exploration drilling has been completed to confirm the actual locations of the pits/cells and associated stockpiles, V drains and sumps. • Clearing for the Proposal does not significantly reduce the extent of any regional vegetation association, with <1 % of the pre-European extent and <1 % of the current area remaining for all vegetation associations present within the proposed development envelope. • No vegetation associations would be cleared below the 'threshold level' of 30 % of its pre-clearing extent. • No Threatened, Endangered or Priority Ecological Community would be impacted by the Proposal. • No direct impacts to the Mount Manning Nature Reserve, Mount Manning—Helena–Aurora Range Conservation Park or the Die Hardy Class A Reserve would occur. These sensitive receptors are greater than 9 km from the proposed development envelope and all works associated with the Proposal are confined to a defined development envelope. • The Proposal would result in clearing <1 % of the vegetation within the former Jaurdi Pastoral Lease and <1 % of the vegetation within the Proposed Conservation and Mining Reserve, which is not considered to significantly alter the high biodiversity conservation values of these DPAW managed lands. • Populations of the Priority flora *Calytrix creswellii* (P3) and *Lepidosperma lyonsii* (P3) would not be reduced as a result of implementing the Proposal. • No significant impacts to the potentially conservation significant species, *Lepidosperma* sp. would occur as a result of the Proposal. The implementation of the proposed management measures would achieve the EPA's objective to maintain the conservation status, diversity and productivity of flora and vegetation across the wider Sandy Ridge site.
Terrestrial Fauna	To maintain representation, diversity, viability and ecological function at the species, population and assemblage level.	• Two fauna habitats were mapped within the proposed development envelope; open woodland and shrublands: o Open woodlands: Open eucalypt woodland with an open understorey of shrubs over ephemeral grasses or	• Vegetation clearing would directly remove or possibly fragment fauna habitat. • Gamma radiation exposure to fauna. • Indirect impacts associated with increased light, noise and vibration.	• Pre–clearing surveys would be conducted prior to any ground disturbance to determine if there are any signs of conservation significant fauna activity within the area proposed for clearing.	• Regionally, clearing for the Proposal does not represent a significant impact to fauna habitat, as clearing accounts for less than 1 % of the woodland dominated Beard vegetation associations (141 and 538) and less than 1 % of the shrubland dominated Beard vegetation associations (435 and 437). • A worst case total of 14.60 ha of woodland habitat and 261.45 ha of shrubland habitat (total of 276.05 ha) would be directly disturbed by the Proposal which is considered to be of some value to the conservation significance malleefowl and rainbow bee–eater.

Environmental factor	EPA objective	Existing environment	Potential sources of impacts	Environmental management	Predicted outcome
		scattered spinifex on red sandy clay soils. o Shrubland: Moderately dense to dense sand plain shrubland varying in height from 0.5–1.8m on yellow sandy soils. • Evidence of two conservation significant species was observed in the proposed development envelope; Malleefowl (*Leipoa ocellata*) and Rainbow Bee-eater (*Merops ornatus*). • 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.	• Indirect impacts associated with fauna displacement, increased predation and competition for resources. • Potential for fire. • Potential increase in feral fauna. • Potential injury or death from fauna ingress into a cell or from vehicle collisions. • Indirect impacts from radiation exposure (unlikely). • Possible generation of voide space and subsequent collapse / instability of the cell (unlikely).	• The CEMP would include fauna management measures to minimise, manage and monitor potential impacts on fauna from the Proposal. A list of measures to be included is provided in Section 10.4.4. • Implement fire prevention and management measures as outlined in the Emergency Response and Management Plan. • Rehabilitation of disturbed areas in accordance with the Mine Closure Plan and Waste Facility Closure and Decommissioning Plan (Appendix A.18).	• Fauna habitat within approximately 1,000 m from a blast may be indirectly affected by moderate noise emissions (60–85 dBA). Emissions are temporarily (a few seconds per year) and unlikely to cause permanent damage to any species. • No fauna of conservation significance (listed under the Wildlife Conservation Act 1950 or the EPBC Act) would cease to exist or have its conservation status affected as a result of the Proposal. • No Priority species as listed by DPAW would cease to exist or have its priority status affected as a result of the Proposal. The EPA's objective to maintain representation, diversity, viability and ecological function at the species, population and community level would be met by limiting the amount of ground disturbance and land clearing. In addition, all vehicles will only use defined access tracks.
Inland Waters Environmental Quality	To maintain the quality of groundwater and surface water, sediment and biota so that the environmental values, both ecological and social, are protected.	No evidence of a groundwater aquifer present in the proposed pit / cell area. No surface water receptors in the proposed development envelope.	• Leak/spill from a waste package which may contaminate surface water runoff and groundwater. • Generation of leachate from a stored waste package which may contaminate surface water runoff and groundwater. • Adverse effects on water quality at the Carina pit from abstraction of water.	• Implement the Surface Water Assessment and Management Plan. • Surface water management measures (e.g. roof canopy, operational bunding, V drains and sumps) would be implemented to protect surface water quality by ensuring it is diverted from operational areas. • Spill response operational procedures would be implemented. • Undertake annual groundwater monitoring. • Undertake weather monitoring. • Undertaken subsidence monitoring in accordance	The Proposal was specifically cited in this location because there is little to no evidence of groundwater and surface water receptors. Therefore, proposed operations would not significantly impact these environmental aspects. Based on the scientific evidence and the ongoing commitment to environmental monitoring across the development envelope, the EPA objective for inland waters environmental quality would be achieved.

Environmental factor	EPA objective	Existing environment	Potential sources of impacts	Environmental management	Predicted outcome
				with the Waste Facility Decommissioning and Closure Plan. • Hydrogeological modelling with be verified by collecting soil moisture data and temperatures at various depths above the silcrete to establish soil moisture profiles during rain events and subsequent dry periods.	
Heritage	To ensure that historical and cultural associations, and natural heritage, are not adversely affected.	There are no known records of heritage items (Aboriginal or European) within or in close proximity to the proposed development envelope as confirmed via online database searches (WA Department of Aboriginal Affairs Site Register, State Heritage Register [inHerit], World Heritage Register, National Heritage Register, Commonwealth Heritage Register and the Australian Heritage Database). In addition, a search of the Land, Approvals and Native Title Unit indicated there are no registered native title claims over the proposed development envelope (Government of Western Australia, 2015). Field surveys did not record any heritage items (registered or previously unrecorded) or ethnographic values within the proposed development envelope. The field surveys were conducted in consultation with representatives of the Kapam Native Title Group, Kelamaia Kabu(d)n and Widji Group.	The Proposal would not disturb any known Aboriginal or European heritage sites or interfere with any known cultural associations within the proposed development envelope.	As no heritage sites (registered or previously unrecorded) occur within the proposed development envelope, no additional mitigation measures would be required. In the event that items of potential European historical significance are encountered, work in their immediate vicinity (defined as a 10 metre radius) would stop and the Heritage Council and State Heritage Office would be contacted. Similarly, if items of Aboriginal heritage significance are identified during construction, work in their immediate vicinity would stop and the the Department of Aboriginal Affairs in addition to the Kaparn Native Group, Kelamaia Kabu(d)n and Widji Group would be contacted for further advice. If suspected skeletal remains are discovered during construction, work in their immediate vicinity would stop and the local police and the Department of Aboriginal Affairs would be notified as soon as possible to determine a course of action. Construction works in the area of the remains would not resume until the proponent receives written approval from either the police or from the Department of Aboriginal Affairs, as appropriate.	The Proposal would not result in an adverse impact on cultural heritage values in the region. The EPA objective for this key environmental factor would be achieved.
Human Health	To ensure that human health is not adversely affected.	There are no sensitive receptors located within 5 km of the development envelope. The people (receptors) who may be exposed to chemicals/agents during the waste	The hazards considered to pose the greatest potential risk of adverse human health effects (i.e. injury, illness or death) include:	The primary mechanism to protect human health would be achieved through implementing and adhering to a number of management plans including the	The proponent recognise that risks to human health have extreme to high consequences. However, the provision of multiple barriers of containment around waste, knowledge of waste content, training and supervision of all employees, appropriate personal protective equipment, monitoring of health and continue improvement of waste handling and storage procedures would either avoid or greatly

Environmental factor	EPA objective	Existing environment	Potential sources of impacts	Environmental management	Predicted outcome
		acceptance process are considered to be limited to: • Truck drivers/transporters. • Onsite workers or visitors. Given the remote nature of the facility, there is no credible scenario in which a member of the public could be exposed to a hazard from a material once it has been accepted at the facility.	• exposure to chemicals/agents in waste materials which are released from their packaging (i.e. a leak or a spill). • bushfire emergency. These hazards are considered to pose a moderate risk to human health, where unmanaged. Stringent planning to prevent these situations (and others with lower risks to human health) occurring to the extent practicable and to manage the potential risks if they do inadvertently happen would be implemented.	Operational Strategy, waste acceptance criteria and a detailed Safety Case. The proponent' Safety Case considers risks that may occur whilst operating the proposed Facility and human safety during: • The design, construction and operation of the facility. • Movement and placements of hazardous materials within the site during operations. • The safety of the facility in the very long term after it has been sealed and closed. In addition to a fundamental analysis of the site characteristics and management practices, the safety case draws on best practice examples developed around the world for the safe storage and isolation of various types of wastes based on strict acceptance criteria, and for the construction in geological settings that are internationally recognised as suitable. The outline Safety Case (Appendix A.15) is a living document which would be updated at each step of the development of the facility – during construction, operation and after closure. Human health management measures are also outlined in the following management plans which are provided as appendices to this PER: • Operating Strategy (Appendix A.16). • Radioactive Waste Management Plan (Appendix A.14). • Mine Closure Plan (Appendix A.19). • Waste Facility Decommissioning and Closure Plan (Appendix A.18).	minimise risk to human health. By adopting the proposed engineering designs and adhering to proposed human health management measures, the EPA objective for this factor would be met.

Environmental factor	EPA objective	Existing environment	Potential sources of impacts	Environmental management	Predicted outcome
				• Developing the outline ERMP in Appendix A.22 into a detailed ERMP following the completion of detailed design. • Drinking Water Quality Management Plan (Appendix A.20).	
Rehabilitation and decommissioning	To ensure that premises are decommissioning and rehabilitated in an ecologically sustainable manner.	The development envelope is currently undisturbed with the exception of exploration activities (temporary campsite, drill pads and access tracks).	• A qualitative risk assessment has been undertaken for all aspects of mine and waste facility closure. The outcome of the risk assessment included the identification of 6 planned and 14 unplanned credible risks. The highest residual ranking risks were: • Major earthquake with surface displacement and cracking of the domed caps over the cells. This could lead to subsidence/slumping of the cell and further erosion of the cap (rills and gullies). The loss of cell stability could potentially allow water to infiltrate into the cells, potentially generating leachate from waste packages into the surrounding clay. • Bushfire which may cause injury or death of Threatened / Priority fauna and damage revegetation. • Terrorist attack from a plane crashing into, or bombing of, the cells. This may cause an expulsion of chemical and radioactive waste from the cell to the surface and into the atmosphere. • Failure of revegetation due to degraded topsoil, compacted soils, erosion, fauna predation, lack of seed pre–treatment, no tubestock available, and weed invasion. • Unauthorised access to the Facility and / or accidental deep excavation into a pit (i.e. mineral exploration). This could impact upon human health and potentially lead to injury or death of fauna by falling into the cell.	The proponent would rehabilitate all disturbed areas in accordance with the Mine Closure Plan and Waste Facility Decommissioning and Closure Plan. Rehabilitation would primarily include respreading of topsoil, ripping of surface, revegetation using local species, irrigation in the initial months of establishment and the application of appropriate fertiliser (where appropriate). Decommissioning of infrastructure would occur in phases, depending if it's used for mining/processing or ore, or for the waste facility. Decommissioning schedules are provided in both the Mine Closure Plan (Appendix A.19) and the Waste Facility Decommissioning and Closure Plan (Appendix A.18).	The EPA's objective, to ensure that premises are decommissioning and rehabilitated in an ecologically sustainable manner, would be met. The proponent is committed to continual improvement through the three–yearly revisions of the MCP and WFDCP to ensure that rehabilitation and decommissioning is conducted in an ecologically sustainable manner at closure time.

Environmental factor	EPA objective	Existing environment	Potential sources of impacts	Environmental management	Predicted outcome
			The pit may become unstable and collapse.		
Offsets	To counterbalance any significant residual environmental impacts or uncertainty through the application of offsets.	The proponent has assessed the residual impacts to the Environmental Factors 'flora and vegetation' and 'terrestrial fauna' as a result of clearing (a maximum) 276.05 ha of native vegetation in accordance with the Residual Impact Significance Model (Government of Western Australia, 2014). The only issue which potentially triggers a requirement for an offset relates to the clearing required within the former Jaurdi Pastoral Lease of which 6.44 ha is within the proposed Conservation and Mining Reserve. As this area is only a proposed reserve at this stage, and vegetation is sparse with no Threatened or Priority flora or TECs/PECs in the 6.44 ha area, the potential impact is not considered to be significant enough to warrant an offset. Therefore, the proponent considers that the residual impacts are not significant and the EPA's objective for flora and vegetation and terrestrial fauna can be achieved without the requirement for an offset.			
Pollution management					
Terrestrial Environmental Quality	To maintain the quality of land and soils so that the environment values, both ecological and social, are protected.	The Sandy Ridge Project is located in the centre of a 160 km long and 20 km wide north–northwest trending granitic body (CRM, 2016) covering 3,200 km^2. At Sandy Ridge, the weathered granite is typical 6 m BGL and unweathered/fresh granite is greater than 27 m BGL. The proposed development envelope is located within the Norseman (266) soil landscape mapping zone, within the Kalgoorlie Province as defined by Tille (2006). The soils of the Norseman zone are described as calcareous loamy earths, yellow sandy and loamy earths, red loamy earths, red deep sands and salt-lake soils. The field assessment identified two soil types within the proposed development envelope; Deep Yellow Sand and Red Sandy Duplexes.	• Sterilisation of minerals beneath the cells. • Degradation of stockpiled soils over time. • Gamma radiation exposure on surrounding soils. • Radon emanating from waste cells. • Soil contamination from leaks/spills. • Subsidence and instability of waste cell allowing infiltration of water and generation of leachate. • Change in landform to surrounding landscape.	• Prior to ground disturbance the proponent would conduct detailed baseline soil sampling in accordance with Department of Health and Department of Lands requirements. • Spill response operational procedures would be implemented. The proponent would ensure all operators are trained and familiar with operational procedures and are educated regularly at toolbox meetings. There would be onsite traffic management, including speed limits and two–way communication between all vehicles, to mitigate potential spills.	With the implementation of management and mitigation measures, the EPA objective with respect to terrestrial environmental quality can be met.
Social surroundings					
Amenity	To ensure that impacts to amenity are reduced as low as reasonably practicable.	There are no sensitive receptors located within 5 km of the development envelope. The nearest permanent sensitive receptor to the proposed development envelope is the Carina Iron Ore Village (approximately 52 km away), tourists residing at the Jaurdi Homestead (approximately 51 km away) and Koolyanobbing (approximately 75 km away).	• Diminished quality of life to nearby receptors due to noise emissions. • Decreased amenity to nearby receptors due to increased dust emissions. • Impacts to visual amenity of people utilising the 'Reserve System' (including the Mount Manning Range Nature Reserve, Mount Manning-Helena and Aurora Ranges Conservation Park and the former Jaurdi Pastoral Lease) specifically in terms of:	• Best practice noise management would be implemented during operation of the mine to ensure compliance is achieved with the Environmental Protection (Noise) Regulations 1997. • Dust suppression and management measures would be implemented to minimise dust impacts where possible. This would include: o Application of dust suppression methods along internal access	Impacts on amenity are limited to a small footprint within a vast landscape of similar landscape character. The Proposal would have a very low impact on amenity values. These impacts would be even further reduced through the implementation of mitigation and management measures such as active vegetation rehabilitation once pits have been infilled and capped.

Environmental factor	EPA objective	Existing environment	Potential sources of impacts	Environmental management	Predicted outcome
			• Impacts to nature based tourism that is travel routes and the use of public viewpoints in the existing and proposed Reserve System. • Impacts to scientific study in the existing and proposed Reserve System.	roads and hard stand areas using watercarts during dry, dusty periods. o Weather conditions would be monitored prior to mining activities most likely to generate dust (i.e. vegetation removal, topsoil and subsoil stripping, and blasting). o Dust deposition gauges would be installed on the proposed development envelope boundaries nearest to the IWDF and the former Jaurdi Pastoral Lease and monitored quarterly for the initial 12 months. The final locations of dust deposition gauges would be identified in consultation with the DER. • Disposal cells would be rehabilitated on completion of subsidence monitoring with the objective of producing a surface slightly mounded above the existing nature surface that is vegetated. • Following closure of the mine, all mining related infrastructure would be removed and disturbed areas would be rehabilitated.	

10.2 Flora and vegetation

10.2.1 Introduction

This section provides assesses the potential impacts on flora and vegetation during both construction and operation of the Proposal. Mitigation and management measures are identified to avoid or reduce potential impacts with the objective *to 'maintain representation, diversity, viability and ecological function at the species, population and community level'* in accordance with the EPA's Environmental Assessment Guideline No. 8 (2015a).

This section draws on a number of comprehensive studies including:

- *Sandy Ridge Project Exploration Tenement E16/440 Level 1 Flora and Vegetation Survey* (PGV Environmental, 2015; see Appendix A.3).
- *Sandy Ridge Project Exploration Tenement E16/440 Level 2 Flora and Vegetation Survey* (PGV Environmental, 2016; see Appendix A.3).
- *Environmental Risk from Ionising Contaminants Assessment (ERICA) Modelling* (Hygiea Consulting, 2016; see Appendix A.14).

The assessment has also been prepared with reference to the applicable standards, guidelines and procedures listed in Chapter 4, Table 4-3 and in accordance with the requirements set out in the ESD which is presented in Appendix A.1. A copy of the EPA's checklist for documents submitted for environmental assessment on terrestrial biodiversity is provided in Appendix A.9.

10.2.2 Methodology

A Level 1 Flora and Vegetation Survey was undertaken to assess the flora and vegetation values of the proposed development envelope and to identify the potential presence of flora species or vegetation communities of conservation significance. The Level 1 Flora and Vegetation Survey included the following:

- A review of previous flora and vegetation surveys in the region.
- A review of relevant biodiversity databases for threatened and priority flora species and threatened and priority flora communities that may be affected by the Proposal.
- Examination of recent aerial photography and contour maps to provisionally identify vegetation types and condition.

Based on the results of the Level 1 Flora and Vegetation Survey, a Level 2 Flora and Vegetation Survey was undertaken in accordance with *Guidance Statement 51: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia* (EPA, 2004a). The Level 2 Flora and Vegetation Survey included the following:

- Desktop search and review of DPAW's Declared Rare and Priority Flora database and Threatened Ecological Communities database.

- Examination of recent aerial photography and contour maps to provisionally identify vegetation types and condition.
- Field survey in spring using quadrats (25, 20 m by 20 m quadrats) and several traverses of the access roads and water pipeline route to record native and introduced species, as well as a site walkover of any areas of native vegetation.
- Recording of any significant plant species using a hand–held GPS.
- Description and mapping of vegetation types and vegetation condition.
- Compilation of a flora list.

10.2.3 Assessment of potential impacts and risks

Direct impacts on terrestrial flora and vegetation during construction and operation of the Proposal include the removal of vegetation and impacts on land managed by DPAW. Indirect impacts may include the increased incidence of fire; altered hydrology; dust; the uptake of saline water from dust suppression or from potential water pipeline leaks; and the introduction and spread of weeds. These impacts are discussed below. The potential impacts associated with radiation exposure and the transpiration of leachate are also discussed, although are highly unlikely to occur.

Mitigation and management measures to avoid or reduce impacts on terrestrial flora and vegetation are outlined in Section 10.2.4.

Direct impacts (removal of vegetation)

A total of approximately 276.05 ha of native vegetation would be removed for the construction and operation of the Proposal. This would include the removal of approximately 202.3 ha for the cells, 17.2 ha for the mine infrastructure, 2.5 ha for the accommodation camp, 0.25 ha for the putrescible landfill, 4 ha for the technology park area, 22.2 ha for the access roads and 27.6 ha for the water pipeline.[25]

The clearing of vegetation would initially be undertaken for all disturbance areas except for the cells. This area would be cleared progressively over 25 years (e.g. one cell per year).

Impacts on regional vegetation associations

As discussed in Section 9.1.1, four regional vegetation associations occur within the proposed development envelope, as defined by Beard (1972). An assessment of the impact from the direct clearing of these four vegetation associations is presented in Table 10-2 using data provided in *2014 Statewide Vegetation Statistics Incorporating the CAR Reserve Analysis* (DPAW, 2014).

[25] *Not all of the 202.3 ha footprint of the cells would be used for mining and subsequent waste disposal. Even though the amount of vegetation clearing within this area would be less than 202.3 ha, for the purpose of this assessment it has been assumed that the entire 202.3 ha would be cleared.*

Each of the four regional vegetation associations that occur within the proposed development envelope have greater than 97% of their pre-European extent remaining in the Southern Cross IBRA Subregion. Direct clearing of each vegetation association represents clearing less than 1% of their current remaining extent. All vegetation associations that would be impacted by the Proposal are well represented across the Southern Cross IBRA Subregion. The area proposed to be cleared would not result in any changes to the conservation status of these vegetation associations and, therefore, the overall regional impact on vegetation would not be significant.

Table 10-2 Impacts on regional vegetation associations

Beard vegetation association	Pre-European extent (ha)[26]	Current area remaining (ha)*	Total area within proposed development envelope	Total clearing for Proposal (ha)	Percentage of area remaining directly affected by Proposal (%)
141 – Medium woodland: York gum, salmon gum and gimlet	883,085.69	858,525.04	224.61	18.89	<1%
437 – Shrublands: mixed acacia thicket on sandplain	312,850.92	312,825.96	773.57	254.16	<1%
538 – Eucalyptus open woodland/Triodia open hummock grassland	127,866.58	124,866.81	5.23	2.61	<1%
435 – Acacia sparse shrubland/Cryptandra mixed sparse heath	732,096.18	726,352.32	0.79	0.39	<1%

Impacts on local vegetation types

As discussed in Section 9.1.2, a range of different local vegetation types occur within the proposed development envelope. An assessment of the impact from the direct clearing of each vegetation type is presented in Table 10-3 and is shown graphically in Figure 9-2a and Figure 9-2b.

Table 10-3 Impacts on local vegetation types

Vegetation type (code)	Total area in proposed development envelope (ha)	Total area of clearing (ha)	Clearing as a percentage of total area within proposed development envelope (%)
Ab	0.98	0.49	50.00
Ar	434.18	139.51	32.13
ArAa	0.04	0.04	100
ArEpTs	295.57	92.97	31.45
ArMu	10.91	5.45	49.95
CpAr	2.19	0.08	3.65
EcAt	60.44	4.72	7.81
Eg	150.86	18.22	12.08
EgAaEo	0.91	0.46	50.55

[26] *Source: 2014 Statewide Vegetation Statistics incorporating the CAR Reserve Analysis (DPAW, 2014).*

Vegetation type (code)	Total area in proposed development envelope (ha)	Total area of clearing (ha)	Clearing as a percentage of total area within proposed development envelope (%)
EpMuTs	15.59	2.06	13.21
ErMuAa	2.22	1.11	50.00
EsalMu	1.62	0.81	50.00
EsAt	4.42	1.82	41.18
EsEo	16.11	8.06	50.03
Lr	8.16	0.25	3.06
Total	1004.2	276.05	-

Direct impacts (impacts on vegetation of conservation significance)

No Priority Ecological Communities listed by DPAW, Threatened or Endangered Ecological Communities listed under the WC Act or Threatened or Endangered Ecological Communities listed under the EPBC Act were recorded within the proposed development envelope. Therefore, no Priority Ecological Communities listed by DPAW, Threatened or Endangered Ecological Communities listed under the WC Act or Threatened or Endangered Ecological Communities listed under the EPBC Act would be impacted by the Proposal.

Direct impacts (impacts on flora species of conservation significance)

Two species of conservation significance, *Calytrix creswellii* and *Lepidosperma lyonsii* (both listed as Priority 3 by DPAW), were recorded within the proposed development envelope. An undescribed sedge species was also recorded within the proposed development envelope – *Lepidosperma* sp. This species is currently undescribed and may have some conservation value. The potential impacts on these species are discussed below.

Calytrix creswellii

One population (with more than 100 individuals) of *Calytrix creswellii* was recorded within the proposed development envelope (refer to Figure 9-2a). This population would not be cleared during either construction or operation of the Proposal. This species also occurs outside of the proposed development envelope within the Coolgardie and Murchison Bioregions of the Eremaean Province (Florabase, cited in PGV Environmental, 2016). It has been recorded on nearby sites including the IWDF (Ecologia, 1997), the IWDF Access Road (Mattiske Consulting, 2012) and at the site of the Carina Iron Ore Project (Recon Environmental, 2010).

Mattiske Consulting (2012) recorded many separate populations of the species with population sizes greater than 50, which is considered to be typical for this species. Further surveys outside of the proposed development envelope would likely identify additional populations of this species as it is likely to be more common in the local area/region (PGV Environmental, 2016).

Lepidosperma lyonsii

One population (five individuals) of *Lepidosperma lyonsii* was recorded within the proposed development envelope (refer to Figure 9-2b). This population would not be cleared during construction or operation of the Proposal. This species is known from populations outside of the proposed development envelope and occurs in several locations around Mount Finnerty, Mount Walter and Erayinia Hill near Karonie in the Coolgardie Botanical District.

Regionally, 254 individuals were recorded by Western Botanical (2008), with 37 to 70 individuals recorded by Mattiske Consulting (2009) and one population (number not determined) recorded by Recon Environmental (2010) at the site of the Carina Iron Ore Project. A population (number not determined) was also identified along the IWDF Access Road (Mattiske Consulting, 2012). Barrett (2007) noted that while *Lepidosperma lyonsii* was a poorly known species, it may be more widespread than the current herbarium collections suggest. Further surveys outside of the proposed development envelope would likely identify additional populations of this species as it is likely to be more common in the local area/region.

Lepidosperma sp.

An undescribed sedge species was recorded within the proposed development envelope – *Lepidosperma* sp. Five populations of this species were recorded in vegetation dominated by *Acacia resinimarginea* (refer to refer to Figure 9-2a and Figure 9-2b). Based on the results of current and previous field surveys, the species is likely to be more widespread within the proposed development envelope than the populations recorded. It is also highly likely to occur in numerous locations which would not be impacted by the Proposal. As discussed in Section 9.1.5, the taxonomy of the *Lepidosperma* sp. is currently being reviewed by the WA Herbarium. Its conservation status is currently unknown.

Until the taxonomy and conservation status of this species is known, it is difficult to predict impacts to this species during construction and operation of the Proposal. If the species is deemed to have conservation significance, surveys would be undertaken prior to construction to confirm the presence/absence of the species within the proposed development envelope. If the species is found to be present, significant impacts would be avoided through changes to the location of the proposed infrastructure, if possible. Alternatively, a translocation program developed in consultation with DPAW would be implemented to avoid significant impacts to this species. If significant impacts could not be avoided, the need to calculate and deliver biodiversity offsets would be assessed in accordance with the *Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy* and in consultation with the DoEE and/or DPAW, as appropriate.

Direct impacts (impacts on lands managed by DPAW)

The Proposal is approximately 9.8 km south-east of the Mount Manning Nature Reserve and 19.8 km northeast of the Mount Manning – Helena and Aurora Ranges Conservation Park (refer to Figure 9-7). The Die Hardy Class A Reserve is 79 km to the west. Due to the location of the proposed development envelope, no direct impacts on these conservation areas would occur during construction or operation of the Proposal. The implementation of the Proposal potentially increases the risks associated with fire which could impact upon the conservation values of these areas. However, fire risk is recognised as an operational issue and would be managed through the implementation of a Bushfire Management Plan. Details relating to fire management are discussed further below.

Table 10-4 lists the total area of vegetation to be cleared for the Proposal. The proposed water pipeline would disturb approximately 13.32 ha of vegetation within the former Jaurdi Pastoral Lease, which includes 6.44 ha of vegetation within the proposed Conservation and Mining Reserve. This represents less than 1% of vegetation within the former Jaurdi Pastoral Lease and less than 1% of vegetation within the proposed Conservation and Mining Reserve.

Table 10-4 Impacts on DPAW managed lands

DPAW managed land	Total area (ha)	Area within proposed development envelope (ha)	Total area of clearing (ha)	Percentage of DPAW managed land directly affected by Proposal (%)
Former Jaurdi Pastoral Lease (excludes area of Proposed conservation and mining reserve)	221,355.02	13.76	6.88	<1%
Proposed Conservation and Mining Reserve	68,945.98	13.28	6.44	<1%
TOTAL DPAW MANAGED LAND	**221,355.02**	**27.04**	**13.32**	**<1%**

No flora species of conservation significance or vegetation of conservation significance were identified along the water pipeline route within the former Jaurdi Pastoral Lease and proposed Conservation and Mining Reserve during the field surveys.

As such, there would be no impact on conservation significant flora or vegetation within these DPAW managed areas. In addition, no significant impacts on the values of these areas would occur as the highest concentration of biodiversity conservation values in the region are predominantly associated with banded iron formation (BIF) ranges (EPA, 2007), which are not present within the water pipeline corridor.

Indirect impacts

Indirect impacts on flora and vegetation may include an increased incidence of fire, altered hydrology, increased dust, the uptake of saline water, and the introduction and spread of weeds. These impacts are discussed below. The potential for radiation exposure and the transpiration of leachate from the waste cells are discussed but would not likely occur.

Fire

The proposed development envelope is located within the Goldfields Bushfire Region, which experiences long periods of extreme fire weather in the dry summer months (NRM Rangelands, 2015). Bushfires in this region are mostly started by lightning and while infrequent, under extreme weather conditions they can be large in scale, intense and burn all vegetation types (NRM Rangelands, 2015).

Vegetation in the region (including within the proposed development envelope) comprises a rich mosaic of eucalypt woodlands and dense shrublands, which have contrasting fuel properties and hence fire regime potentials and responses to fire. Fuel in the eucalypt woodlands comprises sparse, usually discontinuous leaf litter and a low understorey of small shrubs, making these fuels of low flammability. In contrast, the often dense shrublands become highly flammable fuel, especially under dry windy conditions (NRM Rangelands, 2015). Fire intervals in the woodlands can be many decades, even centuries, whereas much shorter fire intervals are possible in the more flammable shrublands.

Alteration of the natural fire regime may occur due to improved access and increased human activity associated primarily with flammable liquids, combustible materials and hot machinery used within the proposed development envelope during construction and operation of the Proposal. The risk of causing fire during construction or operation has the potential to increase the frequency of fires in the proposed development envelope.

The potential consequences of an altered fire regime would affect approximately 80.97 ha of woodland vegetation within the proposed development envelope as it is considered to be fire sensitive and is most likely fire independent (i.e. it does not require fire for its persistence) (NRM Rangelands, 2015). Woodland species are obligate seeders which once killed by fire, recruit thereafter from banks of seed buried in soil or encapsulated in woody fruits. The approximately 923.23 ha of shrubland vegetation within the proposed development envelope is well adapted to fire at intervals of a few decades and generally recovers more quickly than woodlands (NRM Rangelands, 2015).

Following a fire, many species are stimulated to reproduce. Plant responses post fire may include:

- Increased productivity.
- Increased flowering.
- Fire stimulated seed release and dispersal.
- Improved seedling germination and establishment through physical and chemical cues such as rupturing of seed coat/smoke and ash.

Fire prevention and management measures would be implemented to minimise bushfires and, therefore, protect native flora species.

Altered hydrology

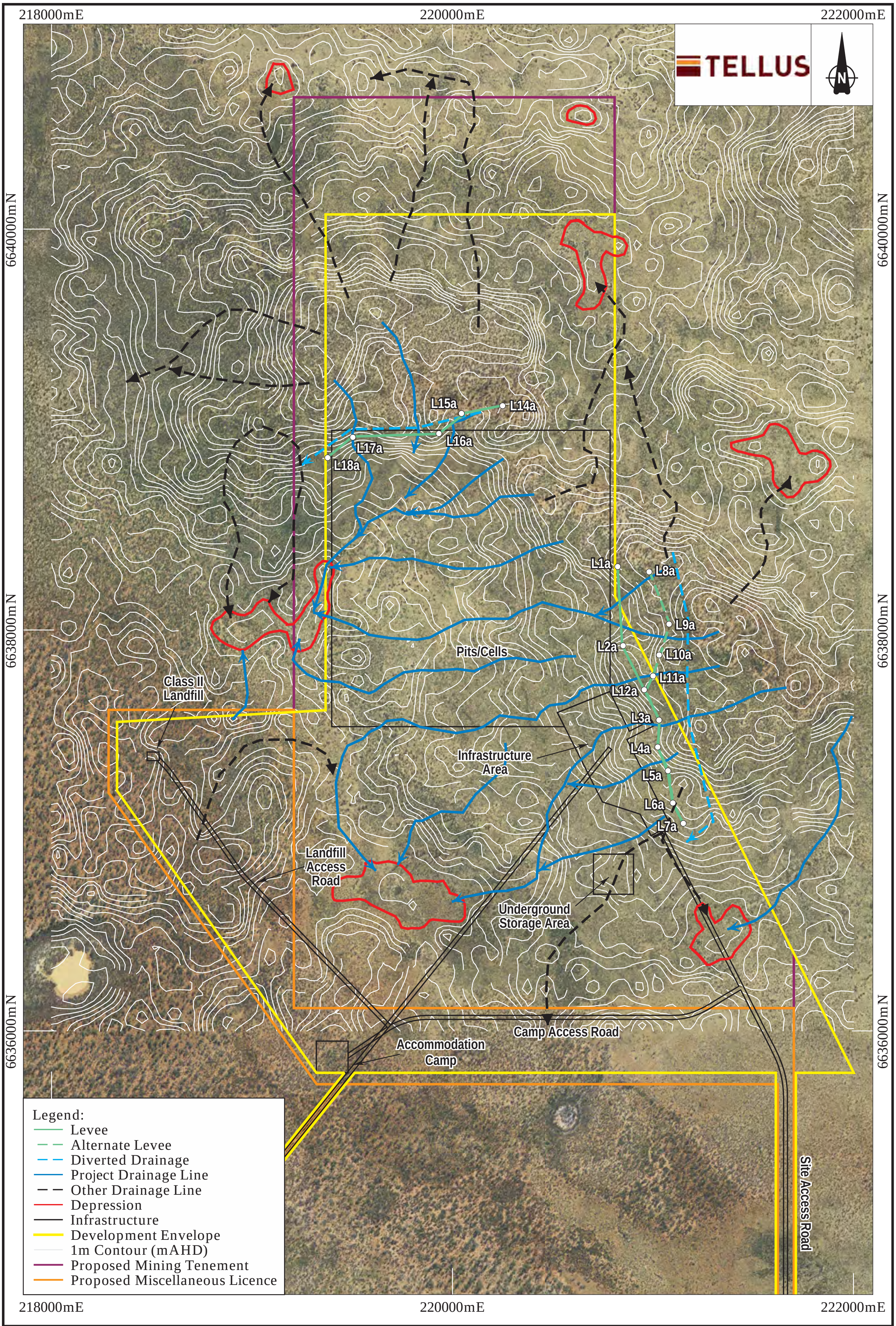
The probability for surface water flows occurring in the development envelope is considered to be very low due to the semi-arid climate of the region. Any surface water flows generated would be restricted to infrequent, but significant storm events.

Typically, rainfall would be intercepted by vegetation or infiltrated within the sandy surficial soils before being lost to evaporation (noting that annual evaporation is approximately eight times more than annual rainfall). However, any residual surface runoff (after infiltration losses) would flow overland following surface topography to lower-lying depressions where it would pool and then evaporate (refer to Figure 10-1).

The potential for indirect impacts on vegetation from the alteration of surface water runoff are considered to be negligible as the likely occurrence of large storm events generating runoff is rare given the semi-arid nature of the region.

To protect the proposed cells, drainage levees would be constructed to divert residual surface water flows around the cells (refer to Figure 10-1). These surface water flows would discharge down gradient of the cells following the natural topography across the landscape eventually infiltrating the soil profile or accumulating temporarily in the same low-lying depressions that would currently receive runoff.

Vegetation within the development envelope, however, is not reliant on surface water runoff for survival due to its location within the 'semi desert Mediterranean' bioclimatic category (Beard, 1990) and the risk of reduced surface water availability for vegetation is considered to be low.



0 400m Scale 1:25,000 MGA94 (Zone 51)	Aurora environmental	**Sandy Ridge Facility**	Figure:
CAD Ref: g2294_PER_09_01.dgn	Author: C. Dorrington | AE Ref: THO2014-003	**Surface water drainage lines, depressions and levees**	**10-1**
Date: November 2016 | Rev: B | A4	Drawn: CAD Resources ~ www.cadresources.com.au Tel: (08) 9246 3242 ~ Fax: (08) 9246 3202	**Public Environmental Review**	

Dust

Impacts on flora and vegetation in the proposed development envelope resulting from dust generating activities would be localised. The main activities likely to create suspended dust particles in the air would be associated with vegetation removal, topsoil and subsoil stripping, blasting, excavation of overburden and ore, backfilling, truck movements and processing of ore. The extent of the dust dispersion would be determined by the intensity of the specific activity and the direction of the prevailing wind conditions.

Dust is more likely to be a hazard close to the cell (i.e. less than 1,000 m), with the hazard decreasing with distance until background dust levels are reached. However, under adverse weather conditions dust can travel considerable distances. Dust accumulation on leaf surfaces can reduce essential plant processes including photosynthesis, respiration and transpiration.

Dust can also produce physical effects on plants such as blockage and damage to stomata, shading, and abrasion of leaf surface or cuticle. This can result in cumulative effects such as drought, stress on already stressed species or lead to decreased plant health and even death in extreme circumstances. Decreased growth and vigour of plants may mean that they are more susceptible to pathogens and other disturbance, and these plants are more likely to be subject to increased mortality. Such impacts on individual plants generally result in decreased productivity and can result in changes in vegetation and community structure (Farmer, 1993).

Although the generation of dust from mining activities is unavoidable, the impacts on flora and vegetation are considered low due to the frequency and extent of each activity. These include the following:

- Vegetation removal and topsoil and subsoil stripping for cells and associated stockpiles would be undertaken annually, over a period of several days only, reducing the extent and volume of dust generated.
- Blasting would likely occur at a frequency of one event per year and would last for a matter of seconds.
- Excavation of overburden and ore, as well as backfilling with overburden, would be undertaken at one cell location per year, primarily below the ground surface, restricting the volume of dust released.
- Truck movements would be limited to four days per week (Monday to Thursday) at an average frequency of nine movements per week.
- The processing plant would be fully enclosed to contain dust emissions. A dust extraction system would be operational during ore processing.

Uptake of saline water from dust suppression

Saline groundwater with concentrations close to seawater would be used for dust suppression activities on hardstand work areas and internal access roads within the proposed development envelope. The consequences of vegetation utilising saline water would include reduced plant regrowth and damage to individual plants, due to either salt impacts on foliage or increased soil salinity.

The water cart spray drift would be designed to spray water across the width of the road, approximately 40 m wide. Some overspray could occur in the prevailing wind direction, which could affect roadside vegetation. The extent of vegetation indirectly affected would be limited to those plants within approximately 2 m of the road verge (a total area of 3.53 ha or less than 1% of vegetation within the proposed development envelope). Death of vegetation is considered unlikely on the basis that water would be applied sparingly to prevent runoff and water would likely evaporate in the semi-arid climate given the high energy and solar evaporation within the proposed development envelope which drives moisture from the soil.

Impacts from saline water used for dust suppression on vegetation within the proposed development envelope is not considered to be significant as less than1 % of vegetation within the proposed development envelope would be indirectly affected.

Uptake of saline water from potential water leaks within the former Jaurdi Pastoral Lease

A rupture or slow leak of saline water along the proposed pipeline route has the potential to impact upon vegetation within the former Jaurdi Pastoral Lease, including the proposed Conservation and Mining Reserve. The impacts on vegetation from utilising saline water include reduced plant growth and damage to individual plants due to either salt impacts on foliage or increased soil salinity.

Although impacts are possible, the risk of saline water significantly impacting vegetation within these DPAW managed areas are considered low, as the pipeline (approximately 110 mm external diameter) would be located with a 10 m wide corridor which would be cleared and kept free of vegetation. The pipeline would be subjected to weekly checks for leaks. However, any water leaking from the pipeline would likely evaporate quickly due to the high rates of evaporation experienced in the region. In addition, as the surficial soils within the proposed development envelope are a mix of predominately coarse (50-70%) and fine (20-30%) grained sands containing minimal clay content (i.e. 3-8%), saline water is likely to infiltrate rapidly rather than runoff.

Introduction and spread of weeds

Environmental weeds are described by DEC (1999) as ‘plants that establish themselves in natural ecosystems and proceed to modify natural processes, usually adversely, resulting in the decline of communities they invade’. Environments affected by mining activities are highly susceptible to invasion by weeds, as disturbances to soils caused by mining operations (i.e. creating bare ground) provide an ideal habitat where weeds can readily colonise and quickly become the dominant vegetation. Weeds pose a key risk, not only during the operational phase of mining, but also during rehabilitation or care and maintenance phases. Weed infestations can compete directly (as well as indirectly) with native or selected revegetation species and can also increase the risk of fires (and fire intensity) that may damage revegetated areas. Weeds have the potential to substantially change the dynamics of natural ecosystems by:

- Competing with or displacing native plant species.
- Affecting natural processes such as fire intensity, stream flows and water quality.
- Changing habitats and therefore impacting on ecosystem health.
- Diminishing natural aesthetic values (DLRM 2012 and Smith 2002).

The proposed development envelope currently contains no environmental weed species, however, it is possible that weeds could be introduced from vehicles movements, mainly from off-site vehicles entering the proposed development envelope. Weeds could then be spread through mining activities such as vegetation removal, topsoil and subsoil stripping, blasting, excavation of overburden and ore, backfilling, truck movements and processing.

Radiation exposure (flora and vegetation)

An assessment was undertaken using the ERICA software tool (refer Appendix A.14). In ERICA, the reference organisms are characterised by their dimensions, the concentration of radionuclides that they exhibit relative to the environmental media with which they are associated and the fraction of the time (occupancy) that they are present within, or at the surface of, the various environmental media.

With this information, dose conversion factors can be used to convert concentrations in organisms into whole-body dose rates, which are then compared to threshold dose rates (dose constrains) (e.g. 10 µGy/h) for various broad categories of organisms to which there are not expected to be significant population effects.

Four exposure scenarios were modelled using ERICA Tier 2 assessments:

- Scenario 1 – exposure of fauna and flora present in the area surrounding the radioactive waste warehouse.
- Scenario 2 – exposure to windblown material originating from operational (kaolin) stockpiles e.g. plant tails; ore, sand, laterite and silcrete stockpiles.
- Scenario 3 – exposure to windblown material originating from ad hoc (waste) stockpiles e.g. low level NORM received as bulk or from emergency clean-up operations.
- Scenario 4 – exposure post closure, with capping material and rehabilitation during the institutional control period.

The above scenarios are highly unlikely to occur because upon closure, with a minimum capping of 7 m, and for the duration of the institutional control period, no risk to non-human biota is foreseen.

The modelled dose rates for all organisms are below the threshold dose rate of 10 µGy/h. External gamma dose rate on surface post closure (minimum cover of 7 m) would be negligible, even if all radioactive waste (2,500,000 tonnes) would be high activity concentration radium scales at an activity concentration of 17,800 Bq/g radium (Ra-226 and Ra-228 combined).

Transpiration of leachate from waste cell

The death of vegetation via transpiration of leachate from the waste cells is not likely to occur. The reasons for this include:

- There would be a separation distance between shallow plant roots and the stored waste. Approximately 7 m of compacted backfill would separate stored waste from the surface. Vegetation would be planted on the topsoil on the domed cap, which is elevated between approximately 1.7 m to 5 m above the ground surface. It is highly unlikely that plant roots would penetrate to the stored waste.
- Leachate would be highly unlikely to be generated from the stored waste, given the lack of groundwater and surface water infiltration into a cell. Engineered controls outlined in the Safety Case specifically exclude water from entering the cell cap.
- In order for planted vegetation to survive, groundwater-dependent species would not be planted. The vegetation planted would be adapted for semi-arid environments and, therefore, would be shallow rooted with a fibrous root system rather than a tap root system which may penetrate deeper.

Vegetation association cumulative impacts

Regional vegetation associations mapping has been used to assess cumulative impacts from the Carina Iron Ore Mine, the IWDF and the Jackson 4 Iron Ore Mine and Haul Road in combination with the Proposal. Regional level mapping has been used rather than local scale mapping, due to the difficulties in comparing vegetation types, which differs substantially between botanists depending on their preferred naming conventions.

Table 10-5 lists the area cleared/proposed to be cleared from each project, and lists the cumulative impacts on the vegetation association. For all affected vegetation associations, less than 1% of their current extent is affected by clearing for all projects combined. Therefore, the cumulative impacts would be negligible and insignificant.

Table 10-5 Cumulative impacts on vegetation

Vegetation association	Current Extent (ha)	Total clearing for Carina Iron Ore Project (ha)	Total clearing for IWDF (ha)	Total clearing for J4 satellite cell (ha)	Total clearing for Sandy Ridge Project (ha)	Cumulative impact (ha)	Impact on current remaining vegetation[27] (%)
141 – Medium woodland; York gum, salmon gum and gimlet	858,525.04	379.10	3.61	536.82	18.89	938.42	0.11
437 – Shrublands; mixed acacia thicket on sandplain	312,825.96	-	71.25	-	254.16	325.41	0.10
538 – Eucalyptus open woodland/Triodia open hummock grassland	124,866.81	39.56	-	10.38	2.61	52.55	0.04
435 – Acacia sparse shrubland/Cryptandra mixed sparse heath	732,470.23	149.33	21.77	162.57	0.39	334.06	0.05
128 – Bare areas; rock outcrops	34,228.77	2.20	1.48	-	-	3.68	0.01
142 – Medium woodland; York gum and salmon gum	11,118.41	3.48	5.03	-	-	8.50	0.08
520 – Shrublands; *Acacia quadrimarginea* thicket	21,214.46	-	-	95.29	-	95.29	0.45
936 – Medium woodland; salmon gum	5,501.81	-	-	10.04	-	10.04	0.18

[27] *Based on current extent remaining in the Coolgardie IBRA Bioregion as per DPAW (2014).*

Evidence of the presence of Rainbow Bee-eater in the region has been documented:

- Two birds were recorded during the field surveys within the proposed development envelope at Sandy Ridge.
- Three records of the bird from two sites (Polaris Metals NL, 2010).
- Approximately 21 records within 50 km of the J4 study area (Polaris Metals Pty Ltd, 2013).

This suggests the migratory bird may frequent the region. The global distribution of the Rainbow Bee-eater is listed by DoE (2016b) as:

The Rainbow Bee-eater is widely distributed throughout Australia and eastern Indonesia, including Bali, the Lesser Sundas and Sulawesi, and east to Papua New Guinea, the Bismarck Archipelago and, rarely, the Solomon Islands. It is a vagrant visitor to locations further north including Palau, south-western Micronesia, Saipan, the northern Mariana Islands, and Miyako Island and the southern Ryuku Islands in Japan.

Given the bird's ability to fly away from disturbance before being affected, and its large distribution and likely low densities in the region, it is unlikely that significant impacts on the Rainbow Bee-eater would occur on a species, population or assemblage level.

10.2.4 Proposed mitigation and management measures

Although impacts on flora and vegetation are not considered to be significant, the following mitigation and management measures would be implemented to further reduce impacts to flora and vegetation during construction and operation of the Proposal.

Construction Environment Management Plan

A Construction Environment Management Plan (CEMP) would be developed which would address potential impacts on flora and vegetation. The CEMP would include the following key mitigation and management measures with respect to flora and vegetation:

- If the *Lepidosperma* sp. is deemed to have conservation significance, surveys would be undertaken prior to construction to confirm the presence/absence of the species within the proposed development envelope. If the species is found to be present, significant impacts would be avoided through changes to the location of the proposed infrastructure, if possible. Alternatively, a translocation program developed in consultation with DPAW would be implemented to avoid significant impacts to this species. If significant impacts could not be avoided, the need to calculate and deliver biodiversity offsets would be assessed in accordance with the *Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy* and in consultation with the DoEE and/or DPAW, as approprite.
- Educate contractors during inductions and regular toolbox meetings regarding the presence of *Calytrix creswellii* and *Lepidosperma lyonsii* within the proposed development envelope.
- Ensure that clearing is kept to a minimum and undertaken progressively, where possible.

- Develop and implement specific clearing procedures, including:
  - Delineation of clearing boundaries with high visibility flagging tape.
  - Clearing authorisation requirements.
  - Supervision of all clearing activities by environmental staff.
- Ensure that the populations of *Calytrix creswellii* and *Lepidosperma lyonsii* are incorporated into mine planning, marked with flagging tape and avoided.
- Implement dust suppression and management measures to mitigate any adverse effects on vegetation including the following:
  - Stabilisation of topsoil stockpiles.
  - Application of dust suppression methods along internal access roads and hard stand areas using watercarts during dry, dusty periods.
  - Monitoring of weather conditions prior to mining activities most likely to generate dust (i.e. vegetation removal, topsoil and subsoil stripping and blasting).
  - Installation of dust deposition gauges in close proximity to the population of *Calytrix creswellii* within the proposed development envelope and at control locations and ensure monitoring is conducted quarterly for 12 months. The final locations of dust deposition gauges would be identified in consultation with DER.
- Monitor vegetation health either side of the surface water diversion levees to determine if water ponding or water starvation is occurring and adversely affecting vegetation.
- Incorporate weed management measures into the CEMP.
- Conduct weekly inspections of the water pipeline to identify leaks and conduct any necessary repairs.

Outcomes/objectives, trigger and contingency actions to ensure impacts on flora and vegetation are not greater than predicted would be included in a Flora and Vegetation Management Plan that would be included as part of the CEMP.

Emergency Response and Management Plan

Fire prevention and management measures would be implemented and outlined in an Emergency Response and Management Plan. These measures would include:

- Hot work permits would be required prior to commencing any activity that may create an ignition source.
- Ensure that fire extinguishers are available in all hot work areas and personnel are trained in their use.

- If necessary, undertake controlled burning of shrubland vegetation under cool mild conditions in consultation with DPAW to reduce the size and intensity of bushfires by burning fuel loads and to reduce the likelihood of fire spreading to fire sensitive woodlands.
- Ensure that emergency response procedures for bushfires and for controlled burning activities are understood and adhered to within and around the proposed development envelope.

Rehabilitation of disturbed areas

All disturbed areas would be rehabilitated in accordance with the Waste Facility Decommissioning Closure Plan (refer Appendix A.18) and MCP (refer Appendix A.19). Rehabilitation would primarily include respreading of topsoil, ripping of surface, revegetation using local indigenous species, irrigation in the initial months of establishment and the application of fertiliser (where appropriate). Further details on rehabilitation are provided in detail in Appendices A.17 and A.19.

10.2.5 Predicted environmental outcome

After implementing the mitigation and management measures described above, the following environmental outcomes are expected in regard to flora and vegetation:

- No more than 276.05 ha of native vegetation would be cleared for the Proposal. The actual area of clearing is likely to be less than this area once exploration drilling has been completed to confirm the planned locations of the cells and associated stockpiles, V drains and sumps.
- Clearing of native vegetation would not significantly reduce the extent of any regional vegetation association, with less than 1% of the pre-European extent and less than 1% of the current area remaining for all vegetation associations present within the proposed development envelope.
- No regional vegetation associations would be cleared below the 'threshold level' of 30% of its pre-clearing extent.
- No Priority Ecological Communities listed by DPAW, Threatened or Endangered Ecological Communities listed under the WC Act or Threatened or Endangered Ecological Communities listed under the EPBC Act would be impacted by the Proposal.
- No direct impacts on the Mount Manning Nature Reserve, Mount Manning – Helena and Aurora Ranges Conservation Park or the Die Hardy Class A Reserve would occur given these areas are greater than 9 km from the Proposal.
- Less than 1% of the vegetation within the former Jaurdi Pastoral Lease and less than 1% of the vegetation within the Proposed Conservation and Mining Reserve would be cleared for the Proposal, which is not considered to significantly alter the high biodiversity conservation values of these DPAW managed lands.

- Populations of *Calytrix creswellii* and *Lepidosperma lyonsii* (both listed as Priority 3 under the WC Act) would not be reduced as a result of the Proposal.

With the implementation of the proposed mitigation and management measures listed above, the EPA's objective to maintain representation, diversity, viability and ecological function at the species, population and community level would be achieved.

10.3 Terrestrial environmental quality

10.3.1 Introduction

This section assesses the potential impacts on terrestrial environmental quality during both construction and operation of the Proposal. Mitigation and management measures are identified to avoid or reduce potential impacts with the objective *to 'maintain the quality of land and soils so that the environment values, both ecological and social, are protected'* in accordance with the EPA's Environmental Assessment Guideline No. 8 (2015a).

This section draws on several comprehensive studies including:

- *Sandy Ridge Project Soils Assessment* (Landloch, 2015; see Appendix A.5).
- *Mine Closure Plan* (See Appendix A.19).
- *Sandy Ridge Landform Evolution Modelling* (Landloch, 2016; see Appendix A.7).
- *Sandy Ridge Project Western Australia Regional Geology and Geological Evolution* (CRM, 2016; Appendix A.4).
- ERICA modelling (Hygiea Consulting, 2016; see Appendix A.14).
- *Radioactive Waste Management Plan* (see Appendix A.14).
- *Safety Case Summary Report* (see Appendix A.15).
- *Waste Facility Decommissioning and Closure Management Plan* (see Appendix 18).

The assessment has also been prepared with reference to the applicable standards, guidelines and procedures listed in Chapter 4, Table 4-3 and in accordance with the requirements set out in the ESD which is presented in Appendix A.1.

10.3.2 Methodology

Land use and topography within and in the vicinity of the proposed development envelope was determined based on a desktop review of publicly available information, a review of aerial photography and via a field reconnaissance survey.

A regional geology and geological evolution report was prepared in order to understand and describe the geology within and in the vicinity of the proposed development envelope. This included a desktop review of publicly available information, a review of geological mapping and a field reconnaissance survey.

A baseline soils assessment was undertaken to characterise and quantify the soil resource within the proposed development envelope. The baseline soils assessment included:

- Desktop review of publicly available information including: Geoscience Australia and Geological Survey of WA mapping, Western Australian Department of Agriculture technical bulletins and online journal articles
- Field assessment, including excavation of four soil cells to 1.5 m below ground level (BGL), for collection of soil samples and logging of soil profiles
- Physical and chemical analysis of collected soil samples, and interpretation of results
- Soil mapping of the proposed development envelope.

Climate data (rainfall, temperature, humidity, wind speed and direction) for the area was obtained from the BoM weather station at Menzies, located approximately 110 km to the north-east of the proposed development envelope. Climate data was also obtained from an Automated Weather Station (AWS) set up within the proposed development envelope in May 2015.

10.3.3 Assessment of potential impacts and risks

Impacts on terrestrial environmental quality during construction and operation of the Proposal include the removal degradation of stockpiled soils; soil contamination from leaks/spills; potential subsidence and instability of a waste cell allowing infiltration of water and generation of leachate; sterilisation of minerals beneath the cells; and a change in landform. These impacts are discussed below. The potential impacts associated with radiation exposure are also discussed, although are highly unlikely to occur.

Mitigation and management measures to avoid or reduce impacts on terrestrial environmental quality are outlined in Section 10.3.5.

Direct impact of soil removal

The mining pit and surface infrastructure would disturb the Deep Yellow Sands, while the accommodation camp and Class II waste storage facility would disturb the Red Sandy Duplex soils (see Table 10-6). GIS software was used to calculate the disturbance area of the roads and racks to the two soil types.

Road corridor disturbance width is assumed to be 20 m and the extent is from the Mt Dimer access road turn off to the Class II waste facility and the entrance to the mining infrastructure.

Table 10-6 Disturbance areas by soil type for the Proposal

Disturbance type	Area (ha)	
	Deep Yellow Sands	Red Sandy Duplex
Mine pit and waste disposal and permanent isolation	37.2 ha	
Mine surface infrastructure	11.8 ha	
Accommodation camp		2.5 ha
Class II waste facility		0.26 ha
Underground storage area	4.0 ha	
Roads and tracks (average 20 m wide)	12.8 ha	5.5 ha
TOTALS	**65.8 ha**	**8.26 ha**

The soil extents within the proposed development envelope are:

- Red Sandy Duplex – 8.26 ha.
- Deep Yellow Sands – 65.8 ha

Recoverable topsoil volumes based on a strip of 10 cm are:

- 8,260 m^3 of Red Sandy Duplex.
- 65,800 m^3 of Deep Yellow Sand.

Recoverable subsoil volumes based on a strip of 20 cm are:

- 16,520 m^3 of Red Sandy Duplex.
- 131,600 m^3 of Deep Yellow Sand.

Both soil types are poorly structured and have a high presence of sand. This means they are likely to be susceptible to erosion, particularly if they are placed on a sloping land surface.

Degradation of stockpiled soils

The creation of cells would require stockpiling of topsoil and subsurface soil for the first 10 years of operations. From years 11 to 25, direct stripping topsoil/subsoil from one cell, could be directly respread on the recently completed cell (i.e. material stripped from cell 11 is placed on cell 1) rather than stockpiled. An identified risk of rehabilitation is the degradation of topsoil and subsoil stockpiles. Stockpiling of soils can lead to compaction, nutrient depletion and loss of seed stock and soil microfauna.

Implementing these principles would mean the risk of stockpile degradation would be low. Topsoil and subsurface soils would be respread with a seed bank of target species and adequate nutrient levels to ensure germination and growth of vegetation.

At mine closure, there would be no residual stockpiles, as these would be incorporated into the final cell landform as per the MCP (see Appendix A.19). Therefore, the soils are expected to maintain their quality and are unlikely to be significantly impacted by the Proposal.

Soil contamination from leaks/spills

Direct contamination of surficial soils could occur from:

- Leak or spill from a solid waste package.
- Leak or spill of dangerous goods stored or used onsite (e.g. diesel).
- Overflow of a contaminated water pond or pad (i.e. when washing down containers), from a leak/crack in a pond liner or from a very low pressure system event which overflows contaminated water from ponds.
- Waste spill during transfer to the cells.
- Bushfire and use of fire-fighting foams and chemical extinguishers.

The consequence of a solid spill from a waste package on soils would be minor as the spill would likely be isolated within the immediate vicinity of the spill site. If the spill were to occur in any of the operational areas (warehouse or receivables pad), these areas would be concreted and bunded and the spill would be unlikely to contact the underlying soil. An identified hazard is a vehicle collision with an ADT which is carrying waste along the road between the infrastructure area and the open cell. If loss of containment occurred, solid waste material could spill onto the surrounding road and cause localised soil contamination, may damage vegetation and toxic dust may disperse from the spill site.

To avoid this, all operators would be trained and familiar with operational procedures and educated regularly at toolbox meetings. There would be onsite traffic management, including speed limits and two-way communication between all vehicles. Visual assessments and rapid clean-up of the spill would ensure the extent of the spill is small, and efficient and effective clean-up would minimise dust generation. With these measures in place, the likelihood of soil contamination would be unlikely and the residual risk would be low.

The refuelling station would consist of a diesel storage tank, pipelines and a bowser. Diesel would be contained in a double walled (self bunded) above ground tank. The refuelling point for plant would have a spill containment unit installed in the ground to capture leaks during refuelling. The bowser would be contained within a self bunded skid unit. Spill kits would be available and the operators working in the area would be trained in operating procedures on how to manage a spill incident, and regular toolbox meetings would be held to continually educate operators. These measures would reduce the likelihood of spilt material affecting the underlying soils to unlikely and the residual risk would be low.

The consequence of a contaminated water overflow from a pond or a waste spill may be moderate as water would likely infiltrate and, therefore, soils at depth could be impacted by a spill, which could take longer to clean-up than a surface spill. It is considered unlikely that contaminated overflow water would impact on soil quality following the implementation of management measures such as:

- Quality assurance/quality control testing on liners.
- Engineering design (which includes 500 mm of freeboard in ponds, and that the ponds are of sufficient capacity to hold washdown and contaminated water).
- Containment of overflow in a secondary sump.
- Implementation of operational procedures including visual inspections of pond/sumps and washdown procedures.

In the event of a cyclone, water could be pumped from the cell into tankers and removed from site prior to heavy rainfalls occurring to ensure the pond would not overflow. To avoid a waste spill contaminating water, wastes would not be transferred into the cells whilst surface water flows are occurring in the infrastructure area, on the internal access road to the cells or in the vicinity of the open cell.

Fire-fighting foam and extinguishers contain chemicals to douse a fire, leaving residual chemicals in the soil following evaporation of water. The consequence of this could be moderate, in the case of a large fire where the use of foams or extinguishers could be extensive. The use of fire extinguishers would be minimised as far as possible, and the soil contamination assessed and remediated in accordance with DER (2014) guidance.

Subsidence and instability of waste cell allowing infiltration of water and generation of leachate

Subsidence and instability of a waste cell could occur if backfilling and compaction activities are not undertaken in accordance with specified procedures. This may lead to the generation of a void space(s) within the cell, which could then cause slumping of the cell backfill, changes to the integrity of the cap, and may generate pathways with greater permeability for water to enter the cell. Water entering the cell could potentially generate leachate from the waste packages.

Impacts on soil quality would be associated with:

- Degradation of the physical structure of soils at the surface (i.e. those that have caved in or collapsed inwards to the cell).
- Soil contamination at the base of the mine void.

Hazards which may contribute to subsidence are primarily related to the backfill and compaction requirements of the engineering design. This would be managed through briefings to the operators from the project engineer, measurements of compaction density undertaken in accordance with *AS1289.5.8.1*, visual inspection following placement of waste and backfill of each layer, and topographical survey at the completion of each layer to confirm engineering specifications have been met and monitoring of the clay dome following cell completion.

Sterilisation of minerals beneath the cells

The proposed development envelope is located in the centre of a 160 km long and 20 km wide north-north-west trending granitic body covering approximately 3,200 km^2 (CRM, 2016). Within the proposed development envelope, the weathered granite is typically 6 m BGL and unweathered/fresh granite is greater than 27 m BGL. The result of disposing of waste within a mine void hosted by weathered granite would permanently prevent access to geological materials located below the cells. This would effectively sterilise materials below the subsurface from any surface soils.

The footprint of an individual cell would be approximately 7,200 m^2 (0.0072 km^2). Assuming 25 cells are constructed over the life of the Proposal, this represents a loss of access to 0.18 km^2 or less than 1% of the land (subsurface). The consequence of this is minor, as subsurface soils are not of social or economic benefit or heritage, hydrological or hydrogeological value (in that they are not part of an aquifer or connected to surface water receptors). The impact of this loss or 'sterilisation' of minerals below the cells is not considered significant, as abundant granite and kaolin are available in the north-north-west trending granitic body. Therefore, the impact on the land quality from sterilisation would be negligible.

Graphical conceptual representation of the final landform

Landform evolution modelling was undertaken by Landloch (Appendix A.7). The modelling was used to predict changes to the landform once mine closure and rehabilitation has been completed. The model incorporated potential changes to the landform over a period of 10,000 years. It included an assessment of:

- Rainfall.
- Average minimum and maximum temperatures.
- Dew point temperature.
- Slope.
- Solar radiation.
- Wind speed and direction.

The model calculates potential erosion rates and sediment loads during different rainfall events/intensities to predict whether the landform would change over time i.e. up to and including 10,000 years. The modelling predicted that there would be relatively little change to the clay domes and the landform is likely to be erosionally stable over the very long term.

A graphical representation of the current view from the west of the proposed development envelope is provided in Figure 10-2. The graphic shows the cells area as vacant, sparsely vegetated land. Figure 10-2 also shows a graphical representation of the final landform with the domed caps of the cells approximately 5 m higher than the surrounding land. The surrounding landscape is mapped by Tille (2006) as Norseman (266); consisting of very low relief, undulating plains and low rises. It is considered that the increased height of the waste cell landforms would likely blend in with the natural topography of the surrounding landscape.

Radiation exposure (land and soils)

An assessment was undertaken using the ERICA software tool (refer Appendix A.14).

Four exposure scenarios were modelled using ERICA Tier 2 assessments:

- Scenario 1 – exposure of fauna and flora present in the area surrounding the radioactive waste warehouse.
- Scenario 2 – exposure to windblown material originating from operational (kaolin) stockpiles e.g. plant tails; ore, sand, laterite and silcrete stockpiles.
- Scenario 3 – exposure to windblown material originating from ad hoc (waste) stockpiles e.g. low level NORM received as bulk or from emergency clean-up operations.
- Scenario 4 – exposure post closure, with capping material and rehabilitation duration the institutional control period.

The above scenarios are highly unlikely to occur because upon closure, with a minimum capping of 7 m, and for the duration of the institutional control period, no risk to non-human biota is foreseen (refer to Section 10.2.3).

The modelled dose rates for all organisms are below the threshold dose rate of 10 μGy/h. External gamma dose rate on surface post closure (minimum cover of 7 m) would be negligible, even if all radioactive waste (2,500,000 tonnes) would be high activity concentration radium scales at an activity concentration of 17,800 Bq/g radium (Ra-226 and Ra-228 combined).

10.3.4 Consistency with the National Waste Policy and Western Australian Waste Strategy

The Proposal would be consistent with the *National Waste Policy: Less Waste, More Resources* or NWP (DoE, 2015a) and the *Western Australian Waste Strategy: 'Creating the Right Environment'* (Western Australian Waste Authority, 2012), as discussed below and in Section 4.6.

The Proposal would not result in an increased production of hazardous waste in WA or within Australia. As discussed in Section 2.4.2, waste volumes in the hazardous waste market between 2014 and 2034 have been estimated by Blue Environment Pty Ltd (2015) (refer to Figure 2-2). The estimates predict that Australia would produce approximately six million tonnes of hazardous waste in 2016. By 2034, the volume of hazardous waste produced is predicted to rise to 10 million tonnes. Of the total volume produced per annum in Australia, the proponent proposes to manage a very small portion of the total volume, as shown in Figure 2-2.

The orange line in Figure 2-2 shows that despite a predicted increase of hazardous waste over the next 20 years, the Proposal is seeking approval for a steady state of 100,000 tonnes (capacity) of hazardous waste per annum. Approval of the Sandy Ridge Facility would not increase the production of hazardous waste in Australia but go a long way to assisting in the legacy waste management issue within WA and Australia.

The benefits of receiving hazardous wastes interstate are that it would also help reduce legacy hazardous waste management issues at those locations. Risks associated with receiving wastes from all over Australia are excluded from this assessment (refer to Section 5.1 for more information).

National Waste Policy

The *National Waste Policy: Less Waste, More Resources* or NWP (DoE, 2015a), agreed by all Australian Environment Ministers in 2009, provides for a coherent, efficient and environmentally responsible approach to waste management in Australia. The policy provides waste management and resource recovery direction to 2020. The aims of the NWP are to:

- Avoid the generation of waste, reduce the amount of waste (including hazardous waste) for disposal.
- Manage waste as a resource.
- Ensure that waste treatment, disposal, recovery and re-use is undertaken in a safe, scientific and environmentally sound manner.
- Contribute to the reduction in greenhouse gas emissions, energy conservation and production, water efficiency and the productivity of the land.

The NWP includes hazardous wastes and substances in the municipal, commercial and industrial, construction and demolition waste streams and covers gaseous, liquid and solid wastes. Radioactive waste is excluded. The policy sets directions in six key areas and identifies 16 priority strategies that would benefit from a national or coordinated approach. The strategies focus on (but are not limited to) sustainability, collaboration, reducing health and safety risks, better packaging management and classification of wastes, reduction in biodegradable wastes sent to landfill, services to remote and regional communities and responsibility to international obligations.

The Proposal would be developed with consideration of the NWP. If implemented, the Proposal would support the following key areas of the policy:

- **Improving the market** – efficient and effective Australian markets operate for waste and recovered resources, with local technology and innovation being sought after internationally.
- **Reducing hazard and risk** – reduction of potentially hazardous content of wastes with consistent, safe and accountable waste recovery, handling and disposal.
- **Tailoring solutions** – increased capacity in regional, remote and Indigenous communities to manage waste and recover and re-use resources.

Western Australian Waste Strategy

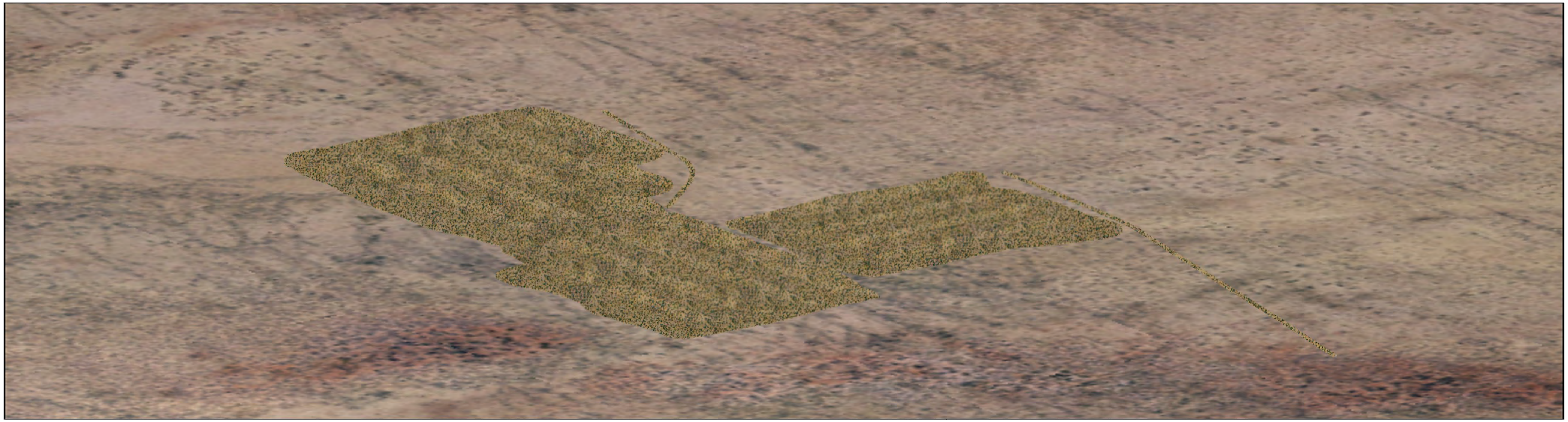
The *Western Australian Waste Strategy: 'Creating the Right Environment'* (Western Australian Waste Authority, 2012) is the primary strategy for waste management and resource recovery in WA. The five objectives of the strategy are as follows:

- **Strategy objective 1** – initiate and maintain long-term planning for waste and recycling processing, and enable access to suitably located land with buffers sufficient to cater for the State's waste management needs.
- **Strategy objective 2** - enhance regulatory services to ensure consistent performance is achieved at landfills, transfer stations and processing facilities.
- **Strategy objective 3** - develop best practice guidelines, measures and reporting frameworks and promote their adoption.
- **Strategy objective 4** - use existing economic instruments to support the financial viability of actions that divert waste from landfill and recover it as a resource.
- **Strategy objective 5** - communicate messages for behaviour change and promote its adoption, and acknowledge the success of individuals and organisations that act in accordance with the aims and principles in the strategy and assist in its implementation.

If implemented, the Proposal would support the objectives of the WA Waste Strategy (particularly Strategy objective 1) by planning for the long-term storage and isolation of hazardous, intractable and LLW that cannot be recycled or recovered, to cater for WA's waste management needs.

Waste disposal cumulative impacts

Situating the Proposal adjacent to an existing Class V landfill (the IWDF) may affect the future use of the land in this locality, but this impact is negated by the fact that the environment is ideal, and potentially the best possible location for the long-term storage of hazardous wastes in WA. By co-locating Class V landfills, this avoids land use conflicts from locating the Facility elsewhere in WA which is a benefit to the State. As there are no pastoral, economic or social values associated with the locality of the IWDF or the Proposal, the cumulative impacts on terrestrial environmental quality is considered insignificant.



TELLUS

Aurora environmental

CAD Ref: g2294_PER_09_02.dgn

Date: Nov 2016 | Rev: B | A4

Author: C. Dorrington | AE Ref: THO2014-003

Drawn: CAD Resources ~ www.cadresources.com.au
Tel: (08) 9246 3242 ~ Fax: (08) 9246 3202

Sandy Ridge Facility

Current and final landform

Public Environmental Review

Figure:

10-2

10.3.5 Proposed mitigation and management measures

The following mitigation and management measures would be implemented with respect to terrestrial environmental quality (following the mitigation hierarchy of avoidance and minimisation):

- Prior to ground disturbance, detailed baseline soil sampling would be undertaken in accordance with the requirements of the Department of Health and Department of Lands to avoid sensitive soils such as highly erodible soils. This management measure would be linked to an overall Construction Environmental Management Plan (CEMP) to ensure soil erosion is avoided and/or minimised in areas characterised as being potentially highly erodible. Contingency measures would include a combination of minimal vegetation removal; silt traps, catch-drains etc. The following principles would be implemented when stockpiling soils:
    - Combined use of a front-end loader, truck and bulldozer would be used to stockpile soils to reduce compaction, not a scraper.
    - Topsoil stockpiles would not exceed 1 m in height and would be flat-topped or slightly domed to maximise water entry. Encouraging water entry would make more water available to plants and minimise the risk of erosion and sediment movement from the stockpile.
    - Subsurface soils (deep yellow sands) would be stockpiled up to 4 m tall and would be flat-topped or slightly domed to maximise water entry.
    - Stockpiles would be monitored for changes in physical and chemical condition. Monitoring should occur at a minimum of every 12 months and should record:
        - Surface condition and erosion.
        - Nutrient status, pH and electroconductivity.
        - Seed germination.
    - If soils are stockpiled for longer than 12 months, they would be fertilised and seeded to reduce erosion, maintain and accumulate soil organic matter and increase soil seed banks.
    - Monitoring of stockpiles for erosion (wind and water) and weed infestation would occur.
- Tree debris including shrubs, brush with trunk diameters greater than 10 cm should be used as erosion protection for stockpiled soil material. In addition, the debris from trees, shrubs, brushes and grasses would add seed, nutrients and organic carbon to the soil.
- Soil striping to the recommend depth of 30 cm should be performed at a time of year when the soil seed bank is highest.
- To avoid compaction of soils, handling of topsoils should not be undertaken when it is wet.

- Spill response operational procedures would be implemented. Visual assessments and rapid clean-up of any spill would ensure the extent of the spill is small, and efficient and effective clean-up would minimise dust generation. This management measure would be linked to a detailed Emergency Response Management Plan (ERMP). The PER currently provides and outline ERMP in Appendix A.22 which would be updated to a detailed management plan once detailed engineering design has been completed for the Proposal.
- All operators would be trained and familiar with operational procedures and are educated regularly at toolbox meetings. There would be onsite traffic management, including speed limits and two-way communication between all vehicles to mitigate potential spills. The proposed CEMP and Operation Environment Management Plan (OEMP) would include provisions for on-site traffic management and internal communications.

In addition, a Mine Closure Plan (AppendixA.19), a Waste Facility Decommissioning and Closure Management Plan (Appendix A.18) and a Radioactive Waste Management Plan (Appendix A.14) have prepared for the Facility. The management objectives for mine closure, rehabilitation and decommissioning are discussed in Section 10.9.4 and summarised in Table 10-7.

Table 10-7 Indicative completion criteria

Trigger	Closure objective	Indicative completion criteria[28]	Management tools
Landform stability	Each excavated pit is structurally stable.	At closure of the pit, walls do not collapse inwards.	Geotechnical assessment.
Safety and security	Each excavated pit is free of ponded water (i.e. not a pit lake).	At closure the mine void does not pose a safety hazard, that persons or vehicles could accidently fall into. The mine void would not contain water of sufficient volume that could create a potential drowning hazard.	Visual inspection. Safety bunding around all open pits.
Vegetation development	Vegetation in rehabilitated areas is comparable as reasonably practicable to the analogue site.	At the completion of the 10 year rehabilitation 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[29] to be introduced into the area.	Re-vegetation monitoring
Decommissioning	Mining related infrastructure (except for that infrastructure to be closed under the WFDCP) removed from site during the Decommissioning Phase.	At mine closure, no mining related infrastructure is left on the tenement.	Visual inspection.

10.3.6 Predicted environmental outcome

The site for the Proposal was specifically chosen in this location because of the lack of groundwater aquifer and surface water receptors, so that the Proposal operations would not significantly impact these environmental aspects.

Therefore, the land and soils of the proposed development envelope would be maintained and would be very unlikely to be significantly affected by the Proposal. With the management and mitigation and contingency measures outlined in Section 10.3.5, the EPA objective to maintain the quality of land and soils so that the environmental values, both ecological and social, are protected would be achieved.

[28] *As described in Appendix K of the MCP guidelines (DMP & EPA, 2015), indicative completion criteria is used in the early stages of closure planning, and may be qualitative or semi–quantitative. As the closure planning progresses the completion criteria would become quantitative.*

[29] *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.*

10.4 Terrestrial fauna

10.4.1 Introduction

This section assesses the impacts on terrestrial fauna during both construction and operation of the Proposal. Mitigation and management measures are identified to avoid or reduce potential impacts with the objective *to 'maintain representation, diversity, viability and ecological function at the species, population and assemblage level'* in accordance with the EPA's Environmental Assessment Guideline No. 8 (2015a).

This section draws on a number of comprehensive studies including:

- *Level 1 Vertebrate Fauna Assessment for the Sandy Ridge Project* (Terrestrial Ecosystems, 2015; see Appendix A.8).
- *Sandy Ridge Project Malleefowl Assessment* (Bamford Consulting Ecologists [BCE], 2016; see Appendix A.8).
- ERICA modelling (Hygiea Consulting, 2016; see Appendix A.14).

The assessment has also been prepared with reference to the applicable standards, guidelines and procedures listed in Chapter 4, Table 4-3 and in accordance with the requirements set out in the ESD which is presented in Appendix A.1. A copy of the EPA's checklist for documents submitted for environmental assessment on terrestrial biodiversity is provided in Appendix A.9.

10.4.2 Methodology

A Level 1 Vertebrate Fauna Assessment was undertaken to assess the fauna values of the proposed development envelope and to identify the potential presence of fauna species of conservation significance. The fauna assessment included:

- A review of previous fauna surveys in the region to determine the potential fauna assemblage for the general area.
- A review of relevant biodiversity databases for Threatened and Priority fauna that may be affected by the Proposal.
- A field reconnaissance survey that included a fauna habitat assessment.
- Targeted threatened fauna searches for Malleefowl (*Leipoa ocellata*).

Based on the results of the Level 1 Vertebrate Fauna Assessment, a Level 2 Vertebrate Fauna Assessment was not required. More information is provided in Appendix A.8.

10.4.3 Assessment of potential impacts and risks

The direct impact on terrestrial fauna during construction and operation of the Proposal would be the loss of habitat (through the removal of vegetation within the proposed development envelope). Indirect impacts may include those associated with increased light, noise and vibration; fauna displacement, increased predation and competition for resources; fire; increased feral fauna attracted to water and food resources; and injury or death from fauna ingress into a cell or from collisions. These impacts are discussed below.

The potential impacts associated with radiation exposure and the generation of void space and subsequent collapse/instability of the waste cell are also discussed, although are highly unlikely to occur. Mitigation and management measures to avoid or reduce impacts on terrestrial flora and vegetation are outlined in Section 10.2.4.

Direct impacts (loss of habitat - regional impacts)

The removal of approximately 276.05 ha of native vegetation would result in the loss of fauna foraging, breeding, roosting, sheltering and/or dispersal habitat. Four regional vegetation associations occur within the proposed development envelope, as defined by Beard (1972). Each of the four regional vegetation associations that occur within the proposed development envelope have greater than 97% of their pre-European extent remaining in the Southern Cross IBRA Subregion. Direct clearing of each vegetation association would represent clearing less than 1% of their current remaining extent. These impacts would not have a significant impact on fauna habitat at a regional level.

The Great Western Woodlands covers an area of almost 16 million ha. Clearing of less than less than 1% of the Woodland Beard vegetation associations (141 and 538) would have a negligible and insignificant impact on the values of the Great Western Woodlands.

Direct impacts (loss of habitat - local impacts)

Almost all native fauna relies on native vegetation to provide food, shelter and breeding sites. The removal of vegetation reduces the capacity of habitat to support fauna, potentially leading to the displacement of fauna. Linear clearing for tracks can fragment habitats by partitioning existing activity areas, isolating sections of established communities and altering long and medium-term patterns of movement within established home ranges, particularly for small mammals and reptiles.

Two fauna habitats were identified within the proposed development envelope: open woodlands and shrublands. The area and percentage of each habitat type that would be directly impacted during construction and operation of the Proposal is presented inTable 10-8.

Table 10-8 Fauna habitats to be cleared within the proposed development envelope

Habitat type	Total area within proposed development envelope (ha)	Area to be cleared for the Proposal (ha)	Percentage of habitat in the proposed development envelope to be cleared (%)
Woodland	80.97	14.60	18.03
Shrubland	923.23	261.45	28.32
TOTAL	**1,004.20**	**276.05**	**27.49**

A total of approximately 276.05 ha of fauna habitat would be removed for the Proposal. This includes about 14.60 ha of open woodland habitat and 261.45 ha of shrubland habitat which accounts for only 18.03% and 28.32% of these habitat types within the proposed development envelope, respectively. Most fauna species are not confined to a specific habitat type and given the presence of large areas of suitable adjoining habitat, the proposed clearing would not have a significant impact on fauna habitats, nor would it act to fragment fauna habitat.

Clearing of fauna habitat would occur progressively over a 25-year period during the implementation phase of the Proposal. It is also anticipated that the actual area cleared would be less than the estimated 276.05 ha.

The fauna habitat types in the proposed development envelope are abundant and in very good condition within adjacent areas, indicating that the fauna assemblage present in the proposed development envelope would also be abundant in adjacent areas. This is supported by fauna survey data from the:

- Jackson-Kalgoorlie and the Boorabbin-Southern Cross sections of the Eastern Goldfields Biological Surveys (Dell and How, 1985 and McKenzie and Rolfe, 1995).
- Fauna surveys conducted for nearby mining proposals (Ecologia Environmental Consultants, 2001; 2003 and Ninox Wildlife Consulting 2008, 2009a, and 2009b).
- Research of Dickman *et al.* (1991) and Lyons and Chapman (1997).

The above surveys provide an adequate indication of the fauna assemblages likely to be encountered in the proposed development envelope.

Impacts on fauna species of conservation significance

Evidence of two species, Malleefowl (*Leipoa ocellata*) (listed as Vulnerable under the WC Act and the EPBC Act) and Rainbow Bee-eater (*Merops ornatus*) (listed as Migratory under the WC Act and the EPBC Act), were recorded within the proposed development envelope. The potential impacts on these species are discussed below.

An additional four species may possibly occur within the proposed development envelope. These species include sp. 1 Central Long-eared Bat (*Nyctophilus [timoriensis]*), Western Rosella (Mallee) (*Platycercus icterotis xanthogenys*), Fork-tailed Swift (*Apus pacificus*) and Peregrine Falcon (*Falco peregrinus*). Clearing of vegetation from within the proposed development envelope would unlikely have a significant impact on these species. Everything would readily move to adjacent undisturbed vegetation once vegetation clearing commences.

Malleefowl (*Leipoa ocellata*)

No Malleefowl tracks, active mounds or individuals were recorded within the proposed development envelope during the targeted surveys. Densities of Malleefowl are generally greatest in areas with higher rainfall and on more fertile soils where habitats tend to be thicker and there is an abundance of food plants (Benshemesh, 2007). The proposed development envelope may contain suitable habitat for Malleefowl (i.e. Eucalypt woodlands, *Acacia* shrublands, Broombrush), however, the low rainfall received at the site has limited food availability for the species. Given that the available habitat is likely to be marginal for the Malleefowl, and that the species has a wide distribution (all states of Australia except Queensland), the number of individuals frequenting the proposed development envelope is expected to be low.

Malleefowl have previously occurred within the proposed development envelope but now appear to be absent as a breeding species, at least from the areas surveyed. This may be a consequence of the extensive recent fires (within approximately the last 10 years) which would have reduced the supply of leaf-litter that is essential for the species' breeding mounds. While the breeding distribution of the species would have been limited to areas of gravelly-loam soils, the birds probably foraged widely through all vegetation types within the proposed development envelope. Malleefowl would presumably return to the area when the vegetation is sufficiently mature to support breeding, and a few birds may occasionally pass through the proposed development envelope.

The potential impact on Malleefowl during construction and operation of the Proposal is considered to be very low as there would be no direct impacts on current breeding sites. The species is likely to occur in the proposed development envelope, but only as an occasional visitor. Therefore, the risk of impacts (e.g. injury or mortality) is expected to be very low. Over time, Malleefowl may return to the proposed development envelope and its surrounds as the quality of the habitat improves. However, the species generally favours gravelly soils for mound construction and these soils are found mostly outside of the proposed development envelope.

Rainbow Bee-eater (*Merops ornatus*)

The sandy soils within the proposed development envelope potentially provides suitable breeding habitat for the Rainbow Bee-eater. However, no recently used burrows were observed within the proposed development envelope. Two individuals were observed opportunistically during the field survey. As the nesting period for the Rainbow Bee-eater had finished for the season, it was assumed that the birds were passing through the area. Therefore, it is considered that Rainbow Bee-eaters may be present when transiting across the proposed development envelope only. Impacts on this species during construction and operation of the Proposal would not be significant as there is no evidence of breeding within the proposed development envelope, the species would readily move out of the area if disturbed and there are large areas of suitable adjoining habitat.

Indirect impacts

Indirect impacts may include those associated with increased light, noise and vibration; fauna displacement, increased predation and competition for resources; fire; increased feral fauna attracted to water and food resources; and injury or death from fauna ingress into a cell or from collisions. These impacts are discussed below. The potential impacts associated with radiation exposure and the generation of void space and subsequent collapse/instability of the waste cell are also discussed, although are highly unlikely to occur.

Increased light, noise and vibration

An increase in light within the proposed development envelope from vehicles and machinery could affect nocturnal fauna, potentially disrupting movement and behaviour. Construction activities would also result in an increase in noise levels within the proposed development envelope, which may affect fauna species. Some fauna species would likely tolerate an increase in noise, while others may not, causing them to leave the affected area or making the area less desirable for foraging, nesting and breeding.

Noise associated with blasting during construction is not expected to have a significant impact on fauna (it would not likely result in temporary or permanent hearing loss of fauna in the vicinity of the blasting activities nor would it likely result in fauna injury or death). Blasting is scheduled to occur once per year and would last a matter of seconds. In addition, the area likely to experience the highest disturbance effects from blasting noise would be cleared of fauna and fauna habitat and fenced prior to blasting. Therefore, the probability of fauna being present in close proximity to the blasting area would be low.

Vibration from construction activities such as heavy vehicle movements and from blasting during construction and operation may deter native fauna from using the area near the vibration sources. This may potentially interrupt dispersal within the area if an individual is unwilling to travel through the area where the vibration is detectable, or may cause some species to abandon an area in search of areas where vibration is not detectable.

Fauna displacement, increased predation and competition for resources

The displacement of fauna would occur as a result of the removal of vegetation that would be required to facilitate the construction and operation of the Proposal. Two separate perimeter fences would be erected around the infrastructure area and the Class II landfill to exclude fauna from these operational areas. The clearing for fence installation may contribute to ‘edge effects’. Edge effects can result in the disruption to ecological processes such as predation and dispersal, animal movements and can also change assemblage structure (Terrestrial Ecosystems, 2015). If the fauna species were moving into different habitats as a result of the displacement, this could have an adverse impact upon native fauna through predation and an increase in competition for resources.

Some mammal species are very sensitive to introduced predators and the decline of many mammals in Australia has been linked to predation by the Fox (*Vulpes vulpes*), and to a lesser extent the Feral Cat (*Felis catus*) (Burbidge and McKenzie, 1989). Introduced grazing species such as the Rabbit (*Oryctolagus cuniculus*), Goat (*Capra hircus*), Camel (*Camelus dromedaries*) and domestic livestock can degrade habitats as well as alter the structure and diversity of vegetation that may be a food source for other species and outcompete native species. However, given that displaced fauna would reside within similar habitat outside the perimeter fencing, the disruption to ecological processes is considered to be minor, and unlikely to affect fauna species at a population level.

Fire

Alteration of the natural fire regime as a result of improved access and increased human activity associated primarily with flammable liquids, combustible materials and hot machinery may pose a risk of fire within the proposed development envelope. Fire can result in the loss of fauna habitat and death to some individuals. Similarly, increased fire frequency can lead to alterations to native ecosystems by impacting species regeneration. Fire prevention and management measures would be implemented to minimise bushfires and, therefore, protect native fauna species and their habitat surrounding the proposed development envelope.

Increase in feral fauna attracted to water and food resources

An increase in development and human activity is often associated with an increase in the abundance of introduced species such as the house Mouse (*Mus musculus*), Cat (*Felis catus*), Wild Dog (*Canis lumpus*), Fox (*Vulpes vulpes*) and Rabbit (*Oryctolagus cuniculus*). Increased opportunities for sourcing food and water could lead to an increase in the presence of feral fauna numbers in operational areas (e.g. water storage ponds and Class II landfill) and in areas adjacent to other infrastructure such as the campsite. Increased numbers of feral fauna species may have an adverse impact upon native species (e.g. injury, illness, death or displacement) through predation and competition.

Injury or death from fauna ingress into cell

During or following the excavation of a cell, there is the potential for ground dwelling fauna and birds to ingress into the open excavation resulting in injury or death. In general, each mine cell would be nominally 120 m long, 60 m wide and 23 m deep (depending on local stratigraphy). The profile of an average mine cell is shown in Figure 5-6. The cell would be covered with a roof canopy which may deter birds from entering the cell. The cells area would be fenced and bunds constructed around each cell to prevent fauna ingress. If fauna do enter the cell, ramps for egress would be available. Therefore, the number of individuals that are likely to enter the open cell is limited, and deaths or injury as a result is considered a low residual risk.

Injury or death of fauna from collisions

Vehicle strike can pose a significant risk to some wildlife, particularly but not exclusively to ground dwelling species, including the conservation significant Malleefowl. While some mobile species such as birds have the potential to move away from machinery or vehicles, other species that are less mobile, or those that are nocturnal and restricted to tree hollows, may have difficulty moving. A collision with an individual animal may result in minor injury or death for the animal.

The Proposal involves road construction and the operation of vehicles. Native fauna would need to cross these roads and negotiate moving vehicles, increasing the risk of fauna mortality from vehicle strikes. Although some mortality may occur as a result of vehicle strikes, this is likely to be limited to individuals and it is not expected that collisions from fauna would affect a species at a population level.

Radiation exposure (terrestrial fauna)

An assessment was undertaken using the ERICA software tool (refer Appendix A.14).

Four exposure scenarios were modelled using ERICA Tier 2 assessments:

- Scenario 1 – exposure of fauna and flora present in the area surrounding the radioactive waste warehouse.
- Scenario 2 – exposure to windblown material originating from operational (kaolin) stockpiles e.g. plant tails; ore, sand, laterite and silcrete stockpiles.
- Scenario 3 – exposure to windblown material originating from ad hoc (waste) stockpiles e.g. low level NORM received as bulk or from emergency clean-up operations.
- Scenario 4 – exposure post closure, with capping material and rehabilitation during the institutional control period.

The above scenarios are highly unlikely to occur because upon closure, with a minimum capping of 7 m, and for the duration of the institutional control period, no risk to non-human biota is foreseen.

The modelled dose rates for all organisms are below the threshold dose rate of 10 μGy/h. External gamma dose rate on surface post closure (minimum cover of 7 m) would be negligible, even if all radioactive waste (2,500,000 tonnes) would be high activity concentration radium scales at an activity concentration of 17,800 Bq/g radium (Ra-226 and Ra-228 combined).

Generation of void space and subsequent collapse/instability of the waste cell (terrestrial fauna)

The encapsulation of wastes within each cell is subject to rigorous engineering design and compaction testing to ensure the properties of the constructed cell are a close analogue of the existing geological and hydrogeological conditions at the site.

A feature survey of the cell would be conducted to confirm the cell is constructed in accordance with the engineering design. Therefore, the generation of void space and collapse of cells is considered an extremely unlikely event. If an animal happened to be on the cell and a collapse occurred, the consequence would be slight slumping (if any) of the cap, and potential displacement of the animal. It is highly unlikely that the animal would be injured or killed.

Terrestrial fauna cumulative impacts

Evidence of the presence of Malleefowl in the region has been documented within the proposed development envelope at Sandy Ridge, at the Carina Iron Ore Mine and at the site of the Jackson 4 Iron Ore Mine and Haul Road. Specifically:

- A disused nest mound of the Malleefowl was recorded near the Carina Iron Ore Mine, but outside the exploration tenement (Polaris Metals NL, 2010).
- Secondary evidence of Malleefowl was also found in the form of fresh tracks as well as three mounds (two recently used and moderately old, and one old mound) within the broader

proposal development envelope. The recently used and moderately old mounds were estimated to be between 5 and 25 years old. The fresh tracks were recorded in the south of the disturbance area (Polaris Metals Pty Ltd, 2013).

This suggests Malleefowl are present in the region, but no active mounds have been identified in any of the proposed development envelopes. Only old, disused mounds were identified. Given the lack of active mounds, it is unlikely an important breeding population is supported in the vicinity of the three projects, and it is unlikely cumulative impacts would affect an important breeding population.

While Malleefowl have not been sighted in any of the fauna surveys undertaken for the three projects, its likely occurrence is supported by the evidence of tracks and old mounds. Given the widespread habitat for this species and their large range of occurrence, the densities of the birds in the vicinity of these projects are expected to be low. Therefore, significant cumulative impacts at a species, population and assemblage level are very unlikely.

10.4.4 Proposed mitigation and management measures

Although impacts on terrestrial fauna are not considered to be significant, the following mitigation and management measures would be implemented to further reduce impacts on fauna during construction and operation of the Proposal.

Pre-clearing surveys

Pre-clearing surveys would be conducted prior to any ground disturbance to determine if there are any signs of conservation significant fauna activity within the area proposed for clearing. Fauna present in the clearing area would be encouraged to move to nearby vegetation, or captured and relocated to adjacent habitat away from the clearing area. The capture/relocation would be undertaken by an experienced fauna handler with the appropriate licences in place. If a Malleefowl mound is encountered, the area containing the mound would be demarcated and an assessment would be undertaken to determine if the mound is active or not.

In addition to the above pre-clearing surveys, areas subject to blasting during construction would be cleared of fauna and fauna habitat and fenced prior to blasting.

Construction Environment Management Plan

The CEMP would include the following key mitigation and management measures with respect to terrestrial fauna:

- Educate contractors during inductions and regular toolbox meetings regarding the potential presence of Malleefowl and Rainbow Bee-eater within the proposed development envelope.
- Develop and implement clearing procedures to minimise impacts on fauna (including conservation significant fauna and their habitats). This would include demarcation of areas to be cleared, pre–clearing checks (see above) and authorisation requirements.

- Ensure that clearing is minimised and conducted in stages, where practical. For example, proposed access routes would be aligned with existing roads and tracks, where possible, to reduce the overall clearing footprint and reduce the impacts on fauna habitat.
- Ensure that an experienced fauna spotter/handler is present on-site during clearing activities to conduct daily checks of vegetation to be cleared and to retrieve fauna, if necessary. The fauna spotter would operate under the relevant licence requirements and would be responsible for all activities related to the protection and welfare of individual fauna.
- Ensure that there is no unauthorised driving off designated access roads. Night driving would be limited and vehicle speeds would be restricted around the operational areas.
- Restrict speed limits on internal access roads to minimise the risk of vehicle strike.
- Implement the following vehicle strike procedures:
    a. Report any collisions with Malleefowl or Rainbow Bee-eaters to the DoEE and DPAW.
    b. If regular collisions are occurring, reduce speed limits, and discuss further management measures with DoEE and DPAW, as appropriate.
- Monitor the integrity of the fences regularly to reduce the likelihood of fauna accessing operational areas.
- Design water storage ponds to reduce fauna accessibility and incorporate deterrent devices such as high visibility material flapping.
- Construct artificial water bodies and drains with non-slippery sides and install egress points so that animals that enter a water body can escape.
- Limit the time that a mine waste cell is open (where practicable), to reduce the likelihood of fauna ingress.
- Pets would not be permitted on site.
- Implement control measures (i.e. physical or chemical) if feral fauna numbers increase in operational areas.
- Manage all waste and rubbish appropriately to ensure fauna have no access to scraps or rubbish. This would include placing all rubbish and scraps in closed containers and/or being placed in the site Class II Landfill and covered with soil to prevent fauna access.
- No feeding of native fauna would be permitted.
- Report sightings or mortalities of conservation significant species to DPAW.

Outcomes/objectives, trigger and contingency actions to ensure impacts on fauna are not greater than predicted would be included in a Fauna Management Plan that would be included as part of the CEMP.

Emergency Response Management Plan

Fire prevention and management measures would be implemented and outlined in an Emergency Response and Management Plan. These measures would include:

- Hot work permits would be required prior to commencing any activity that may create an ignition source.
- Ensure that fire extinguishers are available in all hot work areas and personnel are appropriately trained in their use.
- If necessary, undertake controlled burning of shrubland vegetation under cool mild conditions in consultation with DPAW to reduce the size and intensity of bushfires by burning fuel loads and to reduce the likelihood of fire spreading to the fire sensitive woodlands.
- Ensure that emergency response procedures for bushfires and for controlled burning activities are understood and adhered to within and around the proposed development envelope.

Rehabilitation of disturbed areas

All disturbed areas would be rehabilitated in accordance with the MCP and WFDCP. Rehabilitation would primarily include respreading of topsoil, ripping of surface, revegetation using local indigenous species, irrigation in the initial months of establishment and the application of appropriate fertiliser (where appropriate). Further details on rehabilitation are provided in detail in Appendix A.18 and Appendix A.19.

10.4.5 Predicted environmental outcome

After implementing the mitigation and management measures described above, the following environmental outcomes are expected in regard to terrestrial fauna and their habitats:

- No more than 276.05 ha of native vegetation would be cleared for the Facility. Direct clearing of each vegetation association present within the proposed development envelope would represent clearing less than 1% of their current remaining extent within the Southern Cross IBRA Subregion. These impacts would not have a significant impact on fauna habitat at a regional level.
- A total of 14.60 ha of woodland habitat and 261.45 ha of shrubland habitat (total of 276.05 ha) would be directly disturbed by the Proposal which is considered to be of some value to Malleefowl (*Leipoa ocellata*) (listed as Vulnerable under the WA Act and the EPBC Act) and Rainbow Bee-eater (*Merops ornatus*) (listed as Migratory under the WA Act and the EPBC Act).
- No fauna of conservation significance (listed under the WC Act or the EPBC Act) would cease to exist or have its conservation status affected as a result of the Proposal.

- No Priority species as listed by DPAW would cease to exist or have its priority status affected as a result of the Proposal.

With the implementation of the proposed mitigation and management measures listed above, the EPA's objective to maintain representation, diversity, viability and ecological function at the species, population and assemblage level would be achieved. There would be no residual impacts on terrestrial fauna as a result of the Proposal.

10.5 Inland waters environmental quality

10.5.1 Introduction

This section assesses the potential impacts on inland waters during both construction and operation of the Proposal. Mitigation and management measures are identified to avoid or reduce potential impacts with the objective *to 'maintain the quality of groundwater and surface water, sediment and biota so that the environmental values, both ecological and social, are protected'* in accordance with the EPA's Environmental Assessment Guideline No. 8 (2015a).

This section draws on a number of comprehensive studies including:

- *Radioactive Waste Management Plan* (see Appendix A.14).
- *Sandy Ridge Landform Evolution Modelling* (Landloch, 2016; see Appendix A.7).
- *Sandy Ridge Kaolinite Project Surface Water Assessment and Management Plan* (Rockwater, 2016a; see Appendix A.10).
- *Sandy Ridge Kaolinite Project Surface Water Assessment and Management Plan: Addendum* (Rockwater, 2016b; see Appendix A.10).
- *Hydrogeological Studies for the Sandy Ridge Project* (Rockwater, 2015; see Appendix A.11).
- *The Assessment of Long-term Recharge to Encapsulated Waste Isolation Cells – Sandy Ridge Project* (CyMod, 2016; see Appendix A.12).
- *Waste Facility Decommissioning and Closure Management Plan* (see Appendix A.18).
- *Mine Closure Plan* (see Appendix A.19).

The assessment has also been prepared with reference to the applicable standards, guidelines and procedures listed in Chapter 4, Table 4-3 and in accordance with the requirements set out in the ESD which is presented in Appendix A.1.

10.5.2 Methodology

A hydrological study of the proposed development envelope was undertaken. The hydrological study included:

- Demarcation of the catchment areas and waterways likely to impact on the cell area, infrastructure area and access road.

- Hydrological analysis of relevant catchment areas in order to estimate peak run-off for rainfall events ranging from 1 in every 2 years and 1 in every 100 years' average recurrence intervals (ARI), and the extreme probable maximum precipitation (which is a 1 in 2000 year) event.
- Examination of historical rainfall records for nearby weather stations in order to assess the maximum total rainfall and ARI.
- Preparation of intensity frequency duration rainfall curves using the polynomials as recommended by *Australian Rainfall and Runoff* (Institution of Engineers, Australia, 1987).
- Examination of recorded total losses due to evaporation and infiltration in the Mount Walton area in order to estimate realistic peak flows.
- Completion of a surface water hydraulic analysis in order to assess the extent, depths and velocities of natural flow paths likely to impact the cell area, infrastructure area and access road.
- Design and recommendations for preliminary concept flood protection levees for the cell area, infrastructure area and waterway crossings along the access road.

A hydrogeological study of the proposed development envelope was undertaken. The hydrogeological study included:

- Desktop review of regional hydrogeology which included examination of the:
  - Kalgoorlie 1:250 000 Hydrogeological Series Sheet SH51-9 (Kern, 1994).
  - WA Department of Water's Water Information Reporting database.
  - Previous hydrogeological and geotechnical drilling results from other investigations in the vicinity of the proposed development envelope.
- Field investigation of seven bores to depths in the range of 21-49 m BGL.

A conceptual and numerical hydrogeological model of the existing natural system was developed to aid in understanding the hydrogeological processes and water balance that exists within the proposed development envelope (refer to Appendix A.12).

10.5.3 Assessment of potential impacts and risks

Impacts on inland waters during construction and operation of the Facility may include leaks/spills from a waste package which may contaminate surface water runoff and groundwater, the generation of leachate from a stored waste package which may contaminate surface water runoff and groundwater, and adverse effects on water quality at the Carina Pit from the abstraction of water. These impacts are discussed below.

Assessment of peak surface water flows

If unmanaged, flow from catchment E could directly impact the mining area. The 100 year ARI peak flow of 3.93 m^3/s at corss section one, would be slow moving, 88 m wide and 90 mm deep. The results for cross section one suggest that even with an allowance of 500 mm and the overly conservative peak flow, the minimum flood mitigation levee requirements at the eastern boundary of the proposed mining area is lower than the typical nomincal 1.0 m safety bund area around a pit. Therefore, it is recommended that the safety bund be strategically located and sonctructed to act as both a safety bund and a flood mitigation levee.

Cross sections two and three assessed potential durface water flow impacts from the northern perimeter of the proposed mining site. Model results for cross section two show that 1.63 m^3/s discharge would flow at a depth of to 230 mm over a 27 m width. The natural topography of the site, surface water flows would travel against the northern perimeter of the plant site until it reaches a ground level of 473 AHD where it would spread over approximately 375 m width, pond and infiltrate. Residual water, under this modelled scenario, would flow towards lower ground to the west of south-west and away from the proposed mine area.

Cross section three modelling results show surface water flowing to the southern perimeter of the proposed mine area. Here, peak flows would be approximately 3.25 m^3/s at a depth of 110 mm. Similar to the modelled scenario for cross section two, flows are expected to drain away to the west, southwest and away from the mine area.

Leaks/spills and potential generation of leachate

A leak or spill of solid waste material on the ground surface may result in the release of hazardous contaminants into any ponded surface water. If the leak/spill coincided with an extreme rainfall event, it may contaminate surface water runoff, which may then contaminate low lying depressions (shown in Figure 10-1) to which the runoff flows and ponds before evaporating. The consequence of such an event would be degradation of surface water quality and potentially the soils across which the contaminated water flows.

This consequence is considered to be minor, as individual waste packages would be solid, not liquid and therefore not easily leached, and the volume of a spill is likely to be small as one drum holds approximately 200 L and one bulka bag holds a maximum of approximately 2 m^3.

The likelihood of a leak or spill occurring is considered to be very low due to:

- The minimal volumes of surface water that would be present at the time of a spill/leak.
- The various barriers around, and integrity of, the waste package itself.
- Management measures to be implemented as described in Section 10.5.4.

Rockwater's (2016a) rainfall analysis suggests a 1 in 100 year event would see 176 mm of rainfall over a 72 hour period. A 1 in 2000 year event (probable maximum precipitation) would produce 285 mm of rainfall over the same period. Infiltration rates into the sandy soils of the development envelope are estimated to be 500 mm per day (Rockwater, 2016a), while the infiltration rates in the small clay pans present around the proposed development envelope are slightly less, at between 24 mm and 120 mm per day.

Rockwater predicts that ponded surface water from even the highest rainfall events should infiltrate the surface soils within around 12 hours. Any surface water is prevented from migrating vertically more than a few metres due to the presence of the natural silcrete layer in undisturbed areas of the proposed development envelope or the compacted clay cap in the footprint of the cells. During subsequent dry periods, evaporation and evapotranspiration acts to remove this rainfall infiltration from the top few metres of soil. Unless a leak/spill occurs during or up to 12 hours after a large rainfall event, it is unlikely that any surface water would be present at the site of a spill.

The predicted flow paths for surface water are shown on Figure 10-1, with any residual flow, not lost through infiltration, ponding in minor surface depressions prior to evaporating. If a spill occurred during a large rainfall event or within 12 hours of the event, and resulted in contaminated runoff, the impacted water would eventually pond in a depression and the water would evaporate off, potentially leaving some minor residual contaminants on the soil. In this unlikely event, the soil would be treated and managed in accordance with the *Contaminated Sites Act 2003* (WA). All except one of these depressions is located outside of operational areas where waste packages would be handled or stored. The only depression within the operational area is located adjacent to the internal site access road. This depression is approximately 5.72 ha and could be affected if a spill occurred on the internal access road.

V drains constructed on each side of the road would be designed to contain stormwater from the road preventing any contaminated water generated from a spill directly entering the depression and affecting ponded surface water before it evaporates. Due to the semi-arid nature of the environment in which the proposal is located, whilst it is possible that some localised contamination of surface water may occur, the final fate for virtually any rainfall onsite during an incident would ultimately be discharge to atmosphere by evaporation.

Unloading, handling or temporary storage of waste packages prior to disposal and permanent isolaiton in a cell would be undertaken under cover with bunded concrete floors. This effectively precludes the contamination of surface waters or egress of split materials in those circumstances. Handling of waste packages prior to placement in the cell is unlikely to adversely affect surface water quality or affect the environment values of the development envelope.

Management measures, as described further in Section10.5.4, would be implemented to ensure correct handling and storage of waste packages to minimise the likelihood of leaks or spills. Engineered controls would modify surface water flows to avoid surface water entering operational areas where spill or leaks may occur.

Given the lack of surface water receptors within the proposed development envelope, that surface water flows are generated only under extreme rainfall events, the high rainfall infiltration rate into sandy soils, and the small volume of a potential spill/leak, the risk to the quality of surface water is considered very low. Degradation of water quality is further minimised by diversion levees, operational bunding and operational procedures which serve to divert uncontaminated surface water flows away from operational areas. Additional management procedures would ensure that any spills/leaks would be rapidly detected and cleaned up. The ecological and social values of the development envelope are expected to be maintained and protected.

Assessment of direct and indirect impacts on groundwater from waste in disposal cells after capping

Due to site characteristics, there are few credible mechanisms whereby waste disposal operations can realistically impact on groundwater quality.

Although still posing a very low risk of contamination, the only credible mechanism for the deposited waste to contribute to impacts on groundwater quality is a failure of cell containment allowing water to enter the cell and contact stored waste. As all waste to be deposited would be in a solid form, no liquids could leak within the cell.

Although almost all waste would be securely packaged before placement in the cell, it is assumed such packaging would degrade over time and so the packaging itself only provides safeguard during the period of placement, backfilling and capping of the cell. If water enters the cell (e.g. from infiltration of rainfall through the cap) it may enter the pores of the granular material which surrounds the waste packages (either compacted backfill or the natural material in the wall and base of the cell.

If present in sufficient quantity, this water could leach contaminants from the solid waste at a rate determined by the quantity of water and the characteristics of the waste. The resulting contaminated leachate could then migrate vertically through the saprolite until it reached the surface of the underlying granite. The saprolite profile at the site is a very dry material that has a very large capacity to store and retain any leachate.

Contamination can only occur where there is a source, a receptor and a complete pathway connecting the two. To determine if a complete pathways exist for leachate to reach receptors, hydrogeological modelling (CyMod, 2016) was undertaken of four scenarios:

- ***Scenario 1 – Existing conditions***: the objective was to establish that the model can replicate known conditions, thereby confirming that the model correctly simulated the conceptual hydrogeology, which reduces uncertainty in Scenarios 2, 3 and 4. Two cases were simulated: A) using estimated material properties based on soil characteristics, and B) material properties were adjusted based on no runoff of rainfall from a 50 mm event over 12 hours and vegetation being present on the cap.
- ***Scenario 2 – Backfilled and capped cell: lower boundary sensitivity:*** the objective was to simulate a backfilled and capped cell and quantitatively assess the sensitivity of infiltration and seepage to changes in the model's lower boundary condition. The lower boundary represented the top of the unweathered/fresh granite.
- ***Scenario 3 – Backfilled and capped cell: estimate of infiltration and seepage:*** the objective was to simulate a backfilled and capped cell and estimate the infiltration through the compacted clay cap and seepage through the compacted kaolin layer 7 m below the surface

(referred to in the modelling report as the 'kaolinised granite seal') into the granular material that surrounds waste packages.

- ***Scenario 4 – Backfilled and capped cell: high conductivity topsoil and waste rock:*** the objective was to simulate a backfilled and capped cell and estimate the infiltration through the compacted clay cap and seepage through the kaolinised granite seal into the granular material that surrounds waste packages, using a hydraulic conductivity of 5×10^{-5} m/s for the topsoil, yellow clayey sand and laterite layer that sits on the clay cap.

Daily rainfall inputs for the modelling were:

- Scenario 1 used 20 years of historic climate data starting in 1995 (as shown in Figure 4 of Cymod, 2016).
- Scenarios 2 to 4 used repeated cycles of the 10 wettest years since 1890 (refer to Table 10- 9). This climate sequence was used as it may result in a conservative (i.e. larger than would actually occur) estimate of infiltration and seepage under high rainfall conditions.

Table 10-9 Ten wettest years since 1890

Year	Rainfall (mm/annum)
1992	553.8
1999	521.2
1995	499.6
1963	476.6
1974	443.2
1975	412.9
2011	411.6
1915	405.6
2000	399.8
2006	386.9

The Scenario 1 Case A and B results suggest in the existing natural environment all geological materials remain unsaturated.[30] These modelling results correlate well with the results of the exploration drilling and Hydrogeological Assessment (Rockwater, 2015) which suggests the absence of a groundwater aquifer in the saprolite.

Scenario 1 Case A (properties estimated from soil characteristics)

Based on a 100-year simulation using repeated cycles of the last 20 years of historical rainfall data (1995–2015), the soil moisture (as the volumetric fraction of water in a unit volume of soil) is predicted to be 2% to 8% after 100 years in the topsoil, yellow clayey sand and laterite layer. Silcrete is expected to have a soil moisture content of 2% after 100 years. Based on the water balance, most rainfall is evaporated with infiltration into the topsoil/subsoil layer estimated at 0.05 mm/year.

The infiltration below the silcrete layer, which is indicative of rainfall recharge, is modelled on average to be 0.017 mm/year. This modelling result was consistent with the average rainfall recharge, estimated based on a chloride mass balance, which indicated a range from 0.0036 mm/year to 0.10 mm/year. The predicted vertical flux of water under Case A is illustrated in Figure 10-3.

[30] *A region of the subsurface where pores are completely filled with water (i.e. 100 %) is known as the saturated zone. It is important to keep this in mind, as it means for the saprolite to be saturated 40 – 50 % of the pores must be filled with water.*

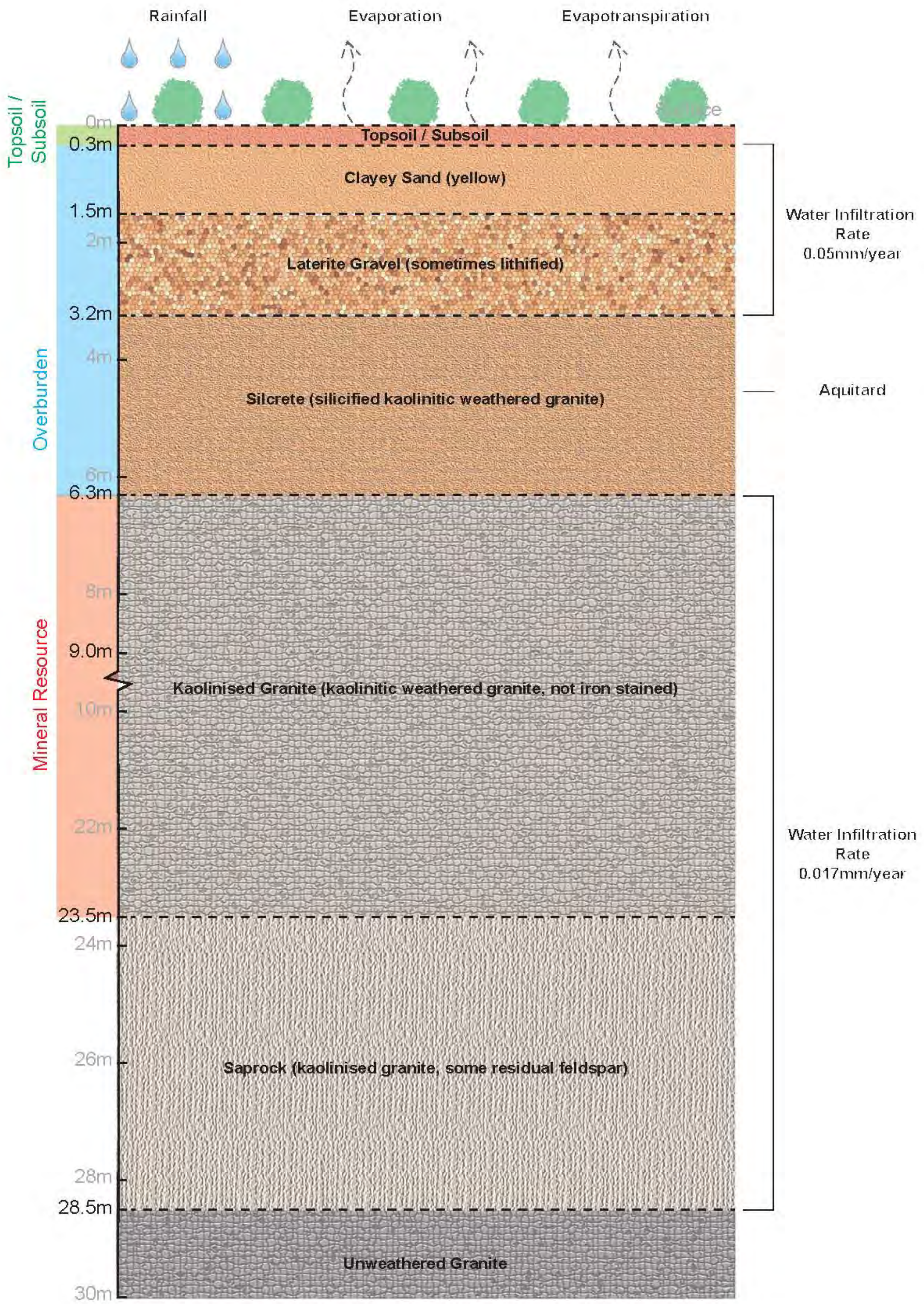


Figure 10-3 Predicted vertical flux of water through the existing natural weathered profile

There is increased saturation at the top of the silcrete, due to the low hydraulic conductivity of this material. The saturation profile confirms that for the climatic conditions simulated and the characteristics of the soil column, it is unlikely that a saturated aquifer would occur either perched above the silcrete or at the interface between weathered and unweathered granite (refer to Figure 10-3).

The modelling predicts that only 2% to 26% of the pore space of the topsoil, yellow clayey sand and laterite layer would be saturated after 100 years. This means the existing geological materials would remain unsaturated.

The low moisture content of soils at Sandy Ridge results in very low unsaturated hydraulic conductivity (i.e. due to very large suction pressures > 10,000 kilopascals [kPa])), which reduces water flow in these soils.

Scenario 1 Case B (soil properties adjusted to reflect no run-off from a 50 mm rainfall event over 12 hours)

Based on a 100-year simulation, the soil moisture and the existing silcrete is predicted to be 2% after 100 years in the topsoil, yellow clayey sand and laterite layer. Based on the water balance, most rainfall is evaporated, with infiltration into the topsoil of 0.175 mm/year. The infiltration below the silcrete layer, which is indicative of rainfall recharge, is on average 0.125 mm/year. The higher recharge in this scenario results from greater surface infiltration.

There is increased saturation at the top of the silcrete, due to it having low hydraulic conductivity. The saturation profile confirms the modelled climatic conditions would not result in groundwater occurring either above the silcrete or at the interface between weathered and fresh granite. The low moisture content of the soils results in very low unsaturated hydraulic conductivity (i.e. due to very large suction pressures greater than 10000 kPa), which reduces water flow in these soils.

The modelling predicts that only 2% to 28% of the pore space of the geological materials would be saturated after 100 years, indicating these geological materials would remain unsaturated.

Discussion – Scenario 1 Case A and Case B

The results of Scenario 1 Cases A and B are consistent with measured water content of sampled soils from exploration holes drilled across the proposed development area, which showed a soil moisture content ranging from 10% to 12% below 6 m BGL. These percentages indicate the soils at Sandy Ridge are very dry.

The reason the geological materials are unsaturated is attributed to the semi-arid environment in which they are located. Sporadic rainfall events (which may be intense) currently result in local runoff, and some infiltration of rainfall into the thin aeolian surface sand. However, during subsequent dry periods, evaporation and evapotranspiration acts to remove this rainfall infiltration from the top few metres of soil, which results in little if any net recharge into the soil profile below the silcrete layer (silcrete acts as an aquitard). Therefore, the natural rainfall/evaporation cycle is:

- Rainfall infiltrates and migrates vertically to the silcrete layer where its velocity is slowed due to the silcrete being relatively impermeable.
- The silcrete is typically within 3 m of the surface, which ensures that any infiltrated water in the soil above the silcrete remains close to the surface where it is subject to evaporation and evapotranspiration.

The Scenario 1 results are consistent with the conceptual hydrogeology and confirm that the model is a reasonable analogue of the existing conditions at the site. Following this confirmation CyMod (2016) then continued simulations with Scenarios 2 to 4 to examine how water would infiltrate the constructed cell, that is, a backfilled and capped cell, and estimated seepage rates.

Water balance

Based on the water balance, most rainfall is evaporated, with infiltration into the topsoil/subsoil layer of 0.21 mm/annum. The infiltration below the silcrete layer, which is indicative of rainfall recharge, is on average 0.0.20 mm/annum.

This scenario shows the sensitivity of recharge to changes in the hydraulic conductivity of the top soil, and how quickly rainfall can infiltrate the soil column. From the results, it is suggested recharge is not sensitive to top soil saturated hydraulic conductivity when it is greater than $1x10^{-6}$ m/sec. This is consistent with the conceptual hydrogeological model, where the low hydraulic conductivity of the silcrete layer acts to impede downward flow, and allow evaporation and evaporation to occur over a longer time.

Scenario 2 – how sensitive is water infiltration and seepage to a change in condition of the unweathered/fresh granite?

This scenario was run using three different conditions:

1. No flow at the lower boundary, which represents impervious unweathered/fresh granite.
2. A specified pore pressure at the lower boundary, which represents elevated saturation at the base of the model (water sitting atop or emanating from unweathered/fresh granite).
3. Unit gradient at the lower boundary, which represents low topographical gradient (e.g. slope or low point) of the unweathered/fresh granite for drainage to depth.

The Scenario 2 results indicate that under all conditions all geological materials remain unsaturated. The water balance shows that the lower boundary condition has no significant impact on the surface boundary change in flows, but does affect the change in storage:

- For the no flow lower boundary (condition 1 above), the change in storage is associated with evapotranspiration of water from shallow soils.

- For the specified pressure boundary (condition 2 above), the saturation in the weathered granite has increased from 12% to 22% due to the lower suction pressure at the boundary over the 20 years compared to the initial condition.
- For the unit gradient (condition 3 above), storage has decreased due to drainage and evapotranspiration.

In effect the model predicts that all of the geological materials remain unsaturated. In general, the lower boundary condition has limited effect on the vertical fluxes, other than for the unit gradient, which tends to increase the vertical flux below the compacted kaolinised granite seal due to the lower saturation in this region and deep drainage.

Scenario 3 –what is the water infiltration and seepage rate into and out of a cell?

In assessing potential impacts on groundwater, it is important to consider whether the climate is likely to remain the same as current day, or whether changes are likely to occur. It is possible that the semi-arid climate of Sandy Ridge could become wetter in future years, and this may affect the infiltration and seepage rates of water into and out of the constructed cell. As described earlier, to account for a worst case wetter climate, the modelling assumed repeated sequences of the 10 wettest years since 1890 to estimate the movement of water that passes through the cell (i.e. vertical flux) (Table 10-9).

Scenario 3 results indicate that all geological materials remain unsaturated after 100 years. Based on the water balance, 69% of rainfall runs off the cell cap and is evaporated, with 31% recharging the shallow surface soils. Infiltration, net recharge to the topsoil/subsoil, is 1.4 mm/year. Vertical flow below the clay cap is 0.8 mm/year, which flows vertically via the compacted silcrete and laterite backfill to the compacted kaolinised granite seal. The vertical flux below the compacted kaolinised granite seal is 0.008 mm/year. This seepage is larger than that estimated for the natural system (0.0017 mm/year), due to the higher hydraulic conductivity of the clay cap and kaolinised granite seal compared to the silcrete.

Based on a seepage rate of 0.008 mm/annum into the waste storage area, over the surface area of a cell (7200 m^2), model results predict about 0.058 m^3/year (58 L/year) of seepage (in a worst case wetter climate) may enter the environment as vertical leakage. This vertical leakage could:

- Be stored within the unsaturated weathered or fresh granite and form a groundwater mound.
- Flow laterally to the north-west following the topography of the fresh granite.

It would be assumed that most of the seepage is retained in the unsaturated weathered granite (i.e. the saprock) directly beneath the cell. The characteristics of the saprock are:

- It is on average about 10 m thick across the cell area.
- Has a porosity of 0.35.
- Initial saturation of 0.1.

This suggests that this material would become fully saturated in about 400,000 years given the estimated seepage rate.

Conversely, if this seepage flows in a thin saturated layer:

- Horizontally to the north-west.
- Under a prevailing gradient of 0.001.
- Through fractures having 1% porosity.
- With an average hydraulic conductivity of 4×10^{-6} m/s.

This equates to a groundwater velocity of 4×10^{-7} m/s, indicating a travel time of about 6,000 years to the most likely exposure point (75 km to the north). In the absence of connected fractures, and flow in the porous weathered granite, the travel time would increase to more than 200,000 years. In either case, the model results suggest the magnitude of seepage potentially emanating from the cell (under wetter climate conditions) is unlikely to mound or move far from the site for a long period of time (centuries).

In reality, these predictions are based on highly conservative assumptions (use of the rainfall data from the 10 wettest years since 1890) and it is considered highly unlikely that a saturated aquifer would ever be created. In the absence of saturation and due to the dry nature of the saprolite overlying the fresh granite, there would be no ability for water to migrate away from the base or sides of the waste cells.

Scenario 4 – what if the topsoil/subsoil is more permeable than we expect?

CyMod (2016) simulated the topsoil/subsoil layer with a hydraulic conductivity of 5×10^{-5} m/s, using the same parameters as Scenario 3 and repeated sequences of the 10 wettest years of climate data (Table 10-9).

The results indicate that with a more permeable soil layer, the geological materials still remain unsaturated after 100 years. There is increased saturation at the top of the clay cap and the compacted clay layer 7 m below the cap due to the low hydraulic conductivities of these materials.

Given that the materials are unsaturated the simulated pressure head is negative, meaning water is not being pushed down through the clay materials, it is unlikely that a saturated aquifer would develop either perched atop the compacted clay layers or at the interface between weathered and unweathered/fresh granite.

Summary of pathways

There are several hydrogeological aspects that would influence the flow of water through a waste cell:

1. Amount of recharge on the cell surface which is directly affected by rainfall, runoff and evapotranspiration.

2. Infiltration rate of water through the compacted clay cap.
3. Infiltration rate of water through the kaolinised granite seal located approximately 7 m below the ground surface.
4. Seepage rate of water at the base of the cell.

A saturated zone would be required in order to induce a plume of contamination. As shown in the four scenarios described above, the geological materials are not predicted to reach saturation even under a wetter climate than currently experienced.

In the worst-case scenario if leachate was generated, Scenario 3 predicts there is:

- Sufficient storage capacity in the saprock directly beneath the cell, to hold seepage for 400,000 years (assuming it moves at a rate of approximately 0.058 m^3/year).
- If water moves to the northwest it would take at least 6000 years to travel to the most likely exposure point (75 km to the north). In the absence of connected fractures, and flow in the porous weathered granite, the travel time would increase to more than 200,000 years.

The model results suggest the magnitude of seepage potentially emanating from the cell (under wetter climate conditions) is unlikely to mound or move far from the site for a long (centuries) period of time.

There are no groundwater bores in the region, with the exception of bores for monitoring purposes at the IWDF (5.5 km east of the proposed development envelope) and water supply bores at the Mount Dimer gold mine, greater than 23 km from the proposed development envelope. This suggests there are no other registered users of groundwater in the vicinity of the Proposal.

The stored waste is a potential source of contamination, if a sufficient quantity of water infiltrates the cell and leaches contaminants from the waste packages. The stimulations indicate the natural soil materials used to construct the cell remain unsaturated even using very conservative climate conditions modelled (i.e. using the wettest 10 years on record to model a 100 year period). Infiltration and seepages rates of water are very low. Assuming a 7,200 m^2 surface area of a cell, this flux equates to 58 L/year of seepage averaged across the cell area under rainfall conditions of continuous wettest years recorded for 100 years.

The saprock beneath the cell has sufficient capacity to hold this volume of water for 400,000 years. If the storage capacity is exceeded, then contaminated water would take between 6000 and 200,000 years, depending on connectivity of fractures to migrate 75 km (note that for much of this distance, the water would be in contact with extremely dry unsaturated clay which would tend to act like a sponge and take up any free water). No receptors have been identified 75 km north of the proposed development envelope. The site selection criteria and engineering design of the cells would ensure ecological and social values of the development envelope are maintained and protected.

Assessment of direct and indirect impacts on wetlands and salt lakes

There are no wetlands or salt lakes within the proposed development envelope.

Surface water flow which is only generated in an extreme rainfall event is likely to follow the natural topography and evaporate or infiltrate within 12 hours (Rockwater, 2016a). The flow trajectory of the natural topography is generally to the north to north-west. There are salt lakes within the vicinity (i.e. 50 km) of the development envelope.

A paleo channel (old or ancient channel) exists approximately 16.5 km east of the cells which joins to Lake Ballard, a salt lake, approximately 112 km north-west from the development envelope. However, the paleo channel is on the opposite side of a hill (approximately 515 m AHD) to the development envelope (approximately 460–490 m AHD). Surface water flow is unlikely to move up gradient and over a hill, and would ultimately in this scenario infiltrate into surficial sands (at a rate of 500 mm/day) or evaporate. As described previously the arid nature and high evaporation and evapotranspiration regime in the region means that little if any water would infiltrate beneath the silcrete. Therefore, it is highly unlikely contaminated or uncontaminated surface water would reach the paleo channel or Lake Ballard, and therefore neither would be affected by the Proposal.

Assessment of potential surface water ingress into mined waste cells

The proponent would implement the proposed Surface Water Assessment and Management Plan (Appendix A.10). Management controls would be in place to prevent water ingress into the mined cell during operation. The cell would be surrounded by operational bunding and V drains that would drain collected surface water to a sump. The water in the sump would evaporate. When waste is being deposited, a roof canopy would be rolled into place to prevent rainfall entering the open cell.

Surface water that could flow into the cells during an extreme rainfall event would be diverted by 0.5 m high bunding/levees as illustrated in Figure 10-1. One levee would be located on the northern boundary of the cells area and one on the eastern boundary to divert water away from the cells area. Diverted water would infiltrate or pond in low-lying depressions where it would evaporate. Details on the proposed levees are provided in the Sandy Ridge Surface Water Assessment and Management Plan (Rockwater 2016a) and its Addendum (Rockwater, 2016b; Appendix A.10). Operational bunding approximately 0.5 m high would be in place around open cells to prevent surface water flowing into the cell from the sides.

The natural characteristics of the site are the main mechanism for groundwater protection. The proposal location was selected largely due to the lack of surface and ground water. As described in Section 2, the position of the development envelope in the regional landscape, the topography, low rainfall, high evaporation rate, high average temperatures and the site stratigraphy and soil types mitigate against the establishment of a groundwater table and anything but the most ephemeral surface water flows or water bodies.

When individual cell locations are drilled prior to blasting, the proponent would ensure that at least 5 m of kaolinised material remains in situ between the bottom of the cells and above the top of the unweathered/fresh granite. This would be achieved through mine planning and grade control drilling. The location of each drill-hole would be surveyed so that any hole penetrations within the cell base are known, and any locations where 'over-drilling' below the cell floor elevation has taken place can be carefully backfilled with compacted kaolinitic material. This process would ensure that the drilling activities do not provide pathways of low permeability soil in the unlikely event that water entered a cell and generated leachate.

Engineering design of the cell and procedural controls around the handling and storage of hazardous and intractable waste would minimise spills and leaks. Spill response operational procedures would be implemented to guide operators on the actions to be taken to contain, clean-up and dispose of spilt material to ensure it does not contaminate surface water flow.

10.5.4 Mitigation and monitoring measures

Runoff observed following high rainfall events should be recorded and used later in the detailed deisgn stage to reassess flood protection requirements.

Monitoring

Annual monitoring of seven bores (listed in Table 10-10) would be conducted for the life of the Proposal.

Table 10-10 Monitoring bores

Bore ID	Location (Zone 51J) Easting	Northing	Depth (m AHD)	(mbtoc[31])	Screened interval (m AHD)	(mbtoc)	Lithology of screened interval
srmb146	219,888	6,637,794	458	30.5	434.38–428.38	24.5–30.5	Kaolinite and deeply weathered granite
srmb147	219,890	6,638,007	458	20.6	444.28–438.28	14.6–20.6	Kaolinite (saprock)
srmb148	219,702	6,637,808	457	24.3	439.7–433.7	18.3–24.3	Kaolinite (weathered granite)
srmb149	220,238	6,637,886	463	22.9	447.25–441.25	16.9–22.9	Weathered granite
srmb150	219,372	6,638,392	455	49	416.07–407.07	40–49	Weathered and fresh granite
srmb151	219,681	6,638,402	457	44.7	418.88–412.88	38.7–44.7	Moderately to slightly weathered granite
srmb152	219,499	6,637,606	455	38.4	423.14–417.14	32.4–38.4	Weathered granite

Shallow monitoring bores would be installed around contaminated water ponds, to assess to monitor any leaks in the liner.

[31] *Methyl Bromide Technical Options Committee*

Weather monitoring would continue for over the course of the Proposal. This involves collecting daily data of the following parameters:

- Maximum wind speed.
- Average wind speed.
- Average wind direction.
- Maximum peak wind gust.
- Maximum relative humidity.
- Minimum relative humidity.
- Average relative humidity.
- Minimum air temperature.
- Maximum air temperature.
- Average air temperature.
- Maximum rain and total rain.

Subsidence monitoring of the capping systems of completed cells would be undertaken on an annual basis in accordance with the WFDCP (Appendix A.18).

Mitigation

In the initial years of operation, the proponent would monitor the success of the diversion levees, operational bunding, V drains and sumps, and would correlate measured peak flow rates with weather data obtained from the onsite weather station to corroborate the hydrological modelling. Data would be used to verify adequacy of surface water flow predictions (i.e. that Lake Ballard would be unaffected even during extreme rainfall events).

Hydrogeological modelling would be verified by collecting soil moisture data and temperatures at various depths above the silcrete to establish soil moisture profiles during rain events and subsequent dry periods. This data would be used to calibrate future unsaturated flow modelling. Future modelling would also incorporate the unsaturated hydraulic conductivity properties of silcrete (once a stockpile of silcrete is available for sampling at the commencement of mining) and backfill material.

Flood flows

It is recommended that the safety bund be strategically located and sonctructed to act as both a safety bund and a flood mitigation levee. The levee length is recommendedto be approximately 545 m long with the highest point been 0.60 m high. On average, the levee would be 0.50 m high.

At crossing points on the proposed access road, it is recommended that a standard floodway and culvert system by construction to manage potential sheet flows.

Once detailed design has been completed, mapping of potental surface water flooding based on the Rockwater report (2015) would be prepared. This information would form part of the proposed CEMP for the Proposal.

Potential infiltration of surface waters

Retaining water near the surface is important so it is allowed to evaporate/evapotranspired. By doing this, it would reduce potential recharge to less than 0.1 mm/year below the proposed clay cap area.

Groundwater and climate monitoring should continue through the development of the Proposal. The monitoring of soil moisture probes to establish soil moisture profiles during rain events and dry periods, and at various depths, was installed in April 2016. The proponent would run analysis of both winter and summer soil moisture data in April 2017 to validate soil moisture profiles at the proposed Sandy Ridge site.

Trigger and contingency actions

If a 1 in 100 ARI event (approximately 136 mm over 24 hours) or larger is forecast, a review would be conducted of the incoming waste to be accepted during that period, and of the scheduled movement of waste into the cell for disposal and permanent isolation. A risk assessment would be undertaken to eliminate potential for spills and, where appropriate, scheduled activities may be postponed. Shipping containers delivered during this period would remain unopened until the rainfall event passes.

In the unlikely event groundwater is detected in the weathered granite profile, this would trigger a review of the hydrogeological modelling to ascertain the groundwater source. Mining and the permanent isolation of waste would be temporarily deferred until the groundwater source is identified and can be protected or until it is confirmed that activities would not significantly affect the groundwater or that the presence of the groundwater does not compromise operational safety.

Assessment of impacts on water quality from sourcing water from the Carina Iron Ore Mine over 25 years

The Facility requires potable water for the accommodation village and administration building and amenities, for use in the laboratory, for use in kaolin processing, for vehicle washdown and for firefighting. Non-potable water (RO reject and raw saline water) would be used for dust suppression and compacting of waste cell backfill and capping.

The proponent would apply for a Licence to Take Water from the Department of Water following completion of the environmental impact assessment (i.e. Part IV) process. It is anticipated that an agreement would be made with Mineral Resources for access to the Carina Pit water via overlapping tenure following the Part IV environmental impact assessment process. The operations at the Carina Pit would be nearing their end around the time that construction of Sandy Ridge would commence. It is unlikely that the two operations would conflict, and discussions held with Mineral Resources representatives indicated that the mine cell is proposed to be left as a mine cell 'lake' at mine closure.

The water within the pit is held within fractured rock and Mineral Resources' licence (GWL 169652) allows for abstraction of 1.6 GL per annum. Significantly less water is proposed to be extracted (estimated at 0.18 GL per annum) than Mineral Resources is currently abstracting.

10.5.5 Predicted environmental outcome

The Sandy Ridge Proposal was specifically cited in this location because the site is void of a groundwater aquifer as well as surface water systems. Owing to a lack of these sensitive environmental values, the proposal's operations would not significantly impact these environmental aspects.

In addition to site selection, the proponent has commissioned modelling using very conservative rainfall/climate assumptions of the hydrogeological regime of both the existing natural environment, and long-term performance of the constructed cells under a range of scenarios. The unsaturated soils provide storage capacity for any minor amounts of water or leachate that may migrate vertically or horizontally from the cells. Without a saturated aquifer, lateral movement of contaminated water from the immediate vicinity of the cells is highly unlikely.

Surface water management measures (e.g. roof canopy, operational bunding, V drains and sumps) would be implemented to protect surface water quality by ensuring it is diverted from operational areas. Due to the high energy environment of the site, surface water evaporates or infiltrates relatively quickly. Confined to extreme rainfall events, if surface water flows are ever generated, they are likely to pond in low-lying depressions and evaporate.

Following closure of the cells, completion of subsidence and revegetation monitoring, cells are expected to be stable, with no water ingress. Landform evolution modelling (Landloch, 2016; Appendix A.7) predicts that after 10,000 years there would be relatively little change to the clay domes and the landform is likely to be erosionally stable over the very long term. Therefore, the groundwater and surface water environment of the development envelope would be maintained both during operations and for geological time following closure.

With the implementation of the proposed mitigation and management measures listed above and those applicable to Section 10.3.5 and Section 10.4.4 that deal with sediment and fauna, the EPA's objective to maintain the quality of groundwater and surface water, sediment and bioata so that the environmental values, both ecological and social would be achieved. Due to the fact, the site is void of groundwater and surface water features, there would be no residual impact on these environmental values as a result of the Proposal.

10.6Human health

10.6.1 Introduction

This section assesses the potential impacts on human health during both construction and operation of the Proposal. Mitigation and management measures are identified to avoid or reduce potential impacts with the objective *to 'ensure that human health is not adversely affected'* in accordance with the EPA's Environmental Assessment Guideline No. 8 (2015a).

This section draws on a number of comprehensive studies including:

- *Baseline Radiation and Metals Report* (Terra Search, 2016; see Appendix A.6).
- *Worker Dose Assessment* (Hygiea Consulting, 2016; see Appendix A.14).
- *Radioactive Waste Management Plan* (see Appendix A.14).
- *Sandy Ridge Project Operating Strategy* (see Appendix A.16).
- *Outline Safety Case* (see Appendix A.15).
- *Drinking Water Quality Management Plan* (see Appendix A.20).
- *Waste Facility Decommissioning and Closure Management Plan* (Appendix A.18).
- *Mine Closure Plan* (Appendix A.19).

The assessment has also been prepared with reference to the applicable standards, guidelines and procedures listed in Chapter 4, Table 4-3 and in accordance with the requirements set out in the ESD which is presented in Appendix A.1.

10.6.2 Methodology

To determine potential risks on human health, modelling was undertaken. The methodology followed the guidance given in the following documents:

- *Managing naturally occurring radioactive material (NORM) in mining and mineral processing – Guideline, DMP* (2010) NORM 5 Dose Assessment (currently under review at the time of submitting this PER)
- *Environmental Health Risk Assessment-Guidelines for assessing human health risks from environmental Hazards* (enHealth Council 2012)
- *Assessing Dose of the Representative Person for the Purpose of the Radiation Protection of the Public. ICRP Publication 101a. Ann. ICRP 36 (3)* (ICRP, 2006)
- *Approved Procedure for Dose Assessment Guideline RSG05* (Department of Industry and Resources, 1997).

The key stages of the assessment below, involved the following:

- Issue identification
- Hazard identification
- Dose–response assessment
- Exposure assessment
- Risk characterisation.

10.6.3 Assessment of potential impacts and risks

Engineering design of the waste cells have been detailed in Section 5.5.4 and illustrated in Figure 5- 12. The conceptual engineering design of the proposed Facility was independently reviewed (refer to Appendix A.21) and concluded "*the design is likely to perform well during the longer term and it appears from the assessments performed that radiation doses will be very low during operations*".

In addition, the independent peer review although recognising there is not yet a clear link between the design and the safety case, which is considered best practice but not considered necessary at this stage, concluded that the design of the waste cells at Sandy Ridge is excellent and that the proposed multibarrier system offers very good prospects of excellent long-term performance that would be comparable or in excess of that for many other LLW disposal facilities in other countries. This is facilitated by the favourable hydrological and hydrogeological environment. Therefore, it can be concluded that risk of human exposure is low.

The independent review identified a number of areas for future work by the proponent which the proponent is aware of, and would be addressing in the next iteration of the Safety Case (Pre-Construction Safety Case), which is to be produced to support licencing activities. Some examples of the items highlighted in the independent review which would be addressed during the development of the PCSR are;

- Radionuclide specific activity limits for the sources that are suitable for disposal in the facility would be set out clearly with consideration of design and site-specific issues. This would be addressed by the production of an assumed inventory which would be used for planning and design purposes.
- Design of the waste store and mechanical handling involving the placing of ILW within the storage shafts would be given particular attention.
- Detailed argument and supporting engineering calculations to demonstrate that the design would perform appropriately.

The waste management plan would be further developed using the principles of optimisation to provide assurance that all aspects of waste storage, handling and emplacement would be appropriately managed.

Impacts on human health during construction and operation of the Proposal may arise from leaks or spills, radiation exposure, radon from waste cells, dust emissions, and the threat of fire. These potential impacts are discussed below.

Leak and spills

The potential for leaks and spills and the assessment of potential associated risks has been assessed in Sections 10.2.3 and 10.3.3.

Radiological exposure during operation

Pathways of radiation exposure giving rise to potential risks on human health during operation were considered and assessed. They included:

- External radiation exposure (ϒ-radiation).
- Inhalation of suspended dust (α radiation).
- Inhalation of radon and decay products.

Exposure to radiation during operation of the proposed Facility is unlikely due to low baseline radiation levels (Appendix A.6) and the very low levels of radioactive material that would be delivered to Sandy Ridge.

However, exposure was considered for activities including:

- Radiation waste and storage.
- Waste placement and burial.
- Earthmoving and contouring.

Based on the *Approved Procedure for Dose Assessment Guideline RSG05* (Department of Industry and Resources, 1997), the following doses were calculated for each workgroup (Table 10-11).

Table 10-11 Dose calculations for work activity per year

Workforce	Gamma dose (mSv/a)	Individual internal dose (mSv/a)	Inhalation of RnDP (mSv/a)	Total dose (mSv/a)
Rad waste receipt and storage	0.400	0.014	0.004	0.418
Waste packaging	0.096	0.002	0.004	0.102
Waste placement/burial	0.004	0.001	0.004	0.009
Chemical waste placement	0.096	0.000	0.000	0.096
Earthmoving and contouring	0.044	0.000	0.000	0.044
Admin and other staff	0.000	0.000	0.000	0.000

Based on current market expectations and uncertainty as to how much LLW would be sent to the Facility, the following exposure hours were assumed (Table 10-12).

Table 10-12 Worker exposure hours

Workforce	Assumed hours per year	Logic of assumed hours
Radiation waste receipt and storage	1000	Unknown. Assume 1000 hours.
Waste Packaging	160	Four packing campaigns a year of five days each.
Waste placement/burial	80	Actual radioactive waste handling component to take 20 hours maximum per campaign. Assuming four campaigns a year.
Chemical waste placement	1920	Full shift assumed.
Earthmoving and contouring	882	Three months.
Admin and other staff	2000	Assuming maximum.

The following exposure levels were assumed based on similar facilities exposure records (Table 10-13).

Table 10-13 Potenital exposure dose levels

Workforce SEG's	µSv/hr expected dose
Radiation waste receipt and storage	0.40
Waste Packaging	0.60
Waste placement/burial	0.05
Chemical waste placement	0.05
Earthmoving and contouring	0.05
Admin and other staff	0

Based on the *Approved Procedure for Dose Assessment Guideline RSG05* (Department of Industry and Resources, 1997) the following doses were calculated for each workgroup (see Table 10-14).

Table 10-14 Dose calculations for each workgroup per year

Workforce	Gamma dose (mSv/a)	Individual internal dose (mSv/a)	Inhalation of RnDP (mSv/a)	Total dose (mSv/a)
Radioactive waste receipt and storage	0.400	0.014	0.004	0.418
Waste packaging	0.096	0.002	0.004	0.102
Waste placement/burial	0.004	0.001	0.004	0.009
Chemical waste placement	0.096	0.000	0.000	0.096
Earthmoving and contouring	0.044	0.000	0.000	0.044
Admin and other staff	0.000	0.000	0.000	0.000

Table 10-14 show that all of the workforce exposure levels would be below the occupational exposure limit of 10 mSv/a, the dose constrain level of 5 mSv and, are highly unlikely to be exposed above the public dose limit of 1 msv/a.

Investigation into exposure levels from similar international facilities indicate that approximately 95% of the staff receive a dose less than 0.1 mSv/a, and 80% less than 0.01 mSv/a. The exposure times at the international facility would be longer that those assumed as Sandy Ridge due to the amount of waste disposed. These levels are within similar range of those calculated above.

Workers involved in the unloading and burial of radioactive waste may be exposed to low levels of external gamma radiation from the waste package, inhalation of suspended dust (α- radiation) and inhalation of radon and decay products. The waste at this stage is packaged and would be lowered into the shafts by mobile equipment. Worker protection includes shielding (provided by the waste packaging and mobile equipment), increased in distance from sources by using mobile equipment and scheduling of waste placement to ensure minimum time is spent near radioactive waste. Exposure is expected to be below 0.01msv/a.

All radiation exposure hazards identified during the baseline qualitative risk assessment were assessed against likelihood of exposure above the exposure limits (20 mSv/a) and above a dose constrain limit of 5 mSv.

Even with an increase of 100% higher than those assumed in the baseline calculations, no dose was above 1 mSv/a. Investigation into exposure levels from similar international facilities indicate that the most exposed worker was around 1.2 mSv/a (individual in charge of traveling crane operations above the disposal vaults). It is therefore unlikely that any person would be exposed to doses above 1.2 mSv/a.

On the basis of the characteristics described above, the initial dose assessments and sensitivity analysis concludes that it is highly unlikely that workers would be exposed to levels above the dose constrain limit of 5 mSv/a. Risks from exposure would be further reduced by following standard guidelines and procedures for the transport and handling of dangerous and hazardous goods. In addition, the separation of LLW from other wastes, in appropriately designed cells, would further reduce the risks of exposure at the proposed Sandy Ridge Facility.

Radiological exposure during post closure

A design objective for the proposed Facility is to provide for the protection of human health and the environment during operation of the Facility, after the facility is closed and, until the time when the associated radiological hazard would reach an insignificant level through natural decay.

A post closure radiological risk assessment was carried out (refer to Appendix A.14) that deals with the post-closure period of the facility, and in particular, the human intrusion scenarios during the period of passive safety and the findings are summarised below.

The dose limit for members of the public from all sources during operations is 1 mSv in a year. During the period of passive safety, a risk target approach is used. This should be considered as the target criteria not to be exceeded in the future. To comply with the risk target during the passive safety period, the waste disposal facility and management systems are designed so that the estimated average dose or risk to members of the public, who, if in the unlikely event, are exposed to radiation at some point in the longer term, shall not exceed a dose constraint of 0.3 mSv in year[32]. To comply with this limit, the proposed Facility has been designed so that the estimated average dose or risk to members of the public, who may be exposed as a result of the disposal facility in the future, shall not exceed the above dose limit but would target 0.3 mSv in a year.

As well as considering passive safety where the disposal system evolves and performs as expected, consideration has been given to human intrusion, this report looks in particular at this. As human intrusion bypasses the designed barriers a dose constraint on 0.3 mSv per year is not felt to be appropriate. ARPANSA[33] advise where it is calculated that human intrusion could result in doses of between 10 and 100 mSv for any human associated with the intrusion, there needs to be further evaluation of the scenario producing this result. The proponent has used a dose of 10 mSv/yr in a number of the human intrusion scenarios analysed.

The post closure risk assessment took into consideration all relevant pathway of exposure, to demonstrate that potential radiological impacts are at acceptable level of risk (as per set dose constrain level) and manageable to adequately safeguard humans.

The post closure risk assessment was undertaken using both first principle calculations and RESRAD modelling software. Five post-closure exposure scenarios were investigated:

- Scenario 1 – First Principle evaluation of human intrusion next to the shaft containing (Category B) sealed radioactive sources that is in accordance to the WAC (refer to Appendix A.24).
- Scenario 2 – RESRAD evaluation of human intrusion - living on exposed bulk waste at activity concentration levels of Category A.

[32] *IAEA-TECDOC-1380 Section 3.3.2*
[33] *Australian Radiation Protection and Nuclear Safety Agency – Licencing of Radioactive Waste Storage and Disposal facilities Section 3.3.5*

- Scenario 3 – RESRAD evaluation of human intrusion - living on exposed bulk waste at activity concentration levels of Category C.
- Scenario 4 – RESRAD evaluation of a recreational visitor to the site post closure.
- Scenario 5 – A reverse calculation using RESRAD evaluation to determine radionuclide activity concentration levels in bulk NORM wastes which would give rise to tolerable exposure conditions for post closure and intrusion scenarios.

The shielding provided from concrete inside a drum, with steel around the drums (refer to Figure 10-4) and concrete in the shafts, is sufficient to shield the radiation from all sources assessed except high activity Caesium-137 sources. By adding 0.0255 m lead shielding (as found in standard source casings) the dose rate is further reduced from 0.16 mSv/hr to 0.02 mSv/hr. With the assumed 40 hours exposure, the dose was calculated as being 0.63 mSV.

This result is below the public dose limit of 1mSv/year. Given the conservative nature of the assessment and, the low probability of event occurring it can be concluded that the risk of human exposure is sufficiently controlled through the proposed design.

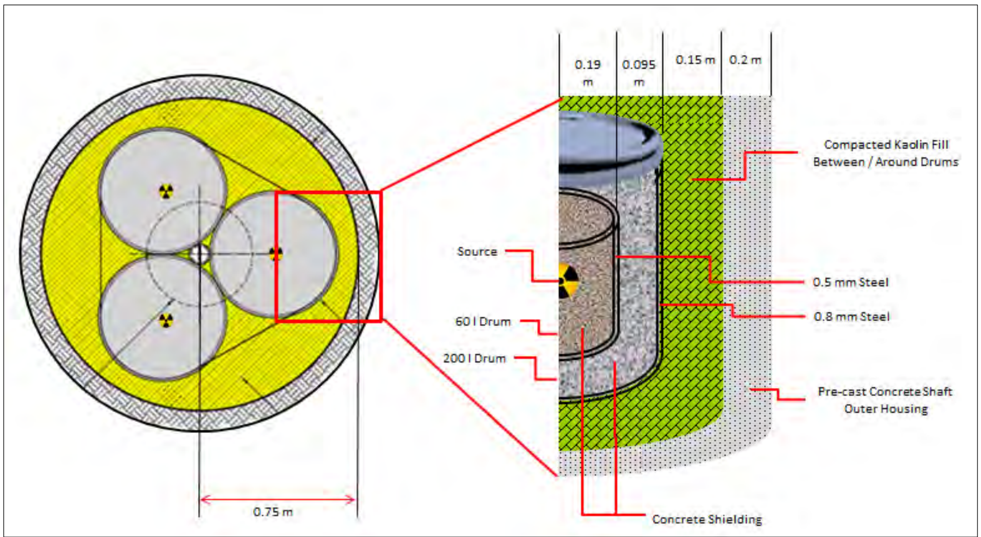


Figure 10-4 Source shielding prior to placement in a concrete shaft

As demonstrated by the results from Scenarios 2 and 3, in the unlikely case where humans would reside on top of exposed bulk waste of category A, an exposure of 587 hours/year would result in total maximum dose of 10 mSv/y. If the exposure would occur on uncapped Category C waste, 6.5 hours occupancy would result in total maximum dose of 10 mSv/y.

In reality, it is implausible that someone would spend this duration in the bulk waste due to site selection of the facility, the cap design and the public notice mitigation illustrated in Figure 10-7.

In the unlikely case where humans would reside on top of exposed bulk waste of category A, a total dose of 112 mSv/y is incurred from occupancies considered being residential (RESRAD default). The dose received is directly proportional to the duration of exposure. Occupancy of 5,870 hours/year would reduce the total maximum dose to 100 mSv/y and 5,87 hours / year would reduce total maximum dose to 10 mSv/y.

From Scenario 3 it was shown that a maximum total dose of 10,170 mSv/y is incurred at 0.6 years after intrusion at occupancies considered being residential (RESRAD default). Occupancy of 65 hours/year would reduce the total maximum dose to 100 mSv/y and 6.5 hours/year would reduce total maximum dose to 10 mSv/y.

External gamma exposure was shown to be the highest contributor to total dose, followed by radon.

From the analysis of Scenario 4 it was shown that a maximum total dose of 6.2×10^{-7} mSv/y is incurred only at 100,000 years after closure, indicating that for the expected land-use post institutional control, no risk to human receptors are foreseen, given that the possibility of intrusion is mitigated through engineering controls.

In Scenario 5, the RESRAD (onsite) code was also used, to determine radionuclide activity concentration levels in bulk NORM wastes which would give rise to conditions as specified above for post closure and intrusion scenarios. These values were adopted in the WAC for NORM waste and are detailed in Table 8 of the post closure risk assessment contained in Appendix 424A.14.

Radon from waste cells

Similar facilities around the world (e.g. France and Spain) indicate very low risk of inhalation of radon products due to the nature of waste disposed, the containment thereof and the half-life of radon. For the purpose of this assessment, it has been assumed the dose due to inhalation of radon gas would be less than 0.004mSv/a. This level is well below the occupational exposure limit of 10 mSv/a.

Generation of void space and subsequent collapse/instability of the waste cell

Section 5.5.4 provide detailed information on the generation of void space and how it would be managed. The information below is an overview of how each cell would be managed to safeguard it against potential collapse and future instability.

Waste packages would be contained within the kaolin mine void. The base and walls of the void would comprise kaolin clays which are naturally impermeable to water. The natural kaolin clay would effectively act as a liner as this material is present in a significant thickness and is more impermeable in the long-term than a synthetic liner (e.g. HDPE, geomembrane or concrete), which would break down and disintegrate over geological time (i.e. 10,000 years).

The waste cells would be filled in layers with multiple sections in each layer containing wastes of similar characteristics. All space between waste packages would be backfilled and compacted to minimise air or void space. If this approach is not taken it may result in settlement. Each layer would be compacted, until approximately 7 m below the ground surface, where a thick capping layer of low permeability clay (referred to as a ‘seal’) would be installed to prevent water ingress into the cell. Following this, more compacted backfill and a clay domed cap would be situated on the top of the cell, to shed any landing rainfall. Figure 5-20 illustrates how co-disposed chemical and radioactive wastes would be contained within the cells.

The encapsulation of wastes within each cell is subject to rigorous engineering design and compaction testing to ensure the properties of the constructed cell is a close analogue of the existing geological and hydrogeological conditions at the site, which naturally excludes water from the kaolinitic soils located beneath the silcrete layer. A feature survey of the cell would be conducted to confirm the cell is constructed in accordance with the engineering design

Dust emission from kaolin mining and subsequently the handling and processing of water material on site

Dust would be generated by all earthmoving operations where vehicles are driving over on-sealed surfaces and excavating or dumping any earthen material. This dust would be controlled by spraying working areas with water from a water-truck equipped with both a dribble bar (for roads) and side-sprays (stockpiles and working surfaces). Fortunately, kaolin clay is an excellent absorber of water and forms a durable crust once wetted and subsequently dried on stockpiles.

The white colour of kaolin also reduces rates of evaporation (when compared to typical Western Australian red dusts) and hence requires less frequent water application to achieve the same level of dust control.

Dust from blasting of the silcrete during mining is not expected to be a significant problem as it would only occur once or twice per year.

The kaolin processing operations would not be dust generating as almost all of the process is conducted as a slurry in water. Only the very final stage of the process involves drying of the kaolin to a damp lump form containing 12% moisture, and some dust may be generated in the dryer which is captured in the exhaust air stream by a dust collector and returned to the process.

The kaolin dust within the drying process is contained within the equipment and might only become a nuisance dust to maintenance workers attending to the dryer and dust collector system. Kaolin is not a classified as a hazardous dust and normal PPE in areas where dust might be present would be a dust mask.

The potential human health hazards from exposure to waste materials during the handling, loading, treatment and re-locating of packaged waste materials into shipping containers or directly into the cells are generally similar to those described above for the acceptance and handling of wastes. These activities increase the likelihood of waste materials being released to the environment, and so overall increase the possibility of exposure to waste materials.

Measures to reduce the likelihood of events occurring where waste materials may be released through these activities would be stringent as outlined in the Sandy Ridge Operating Procedure *SROP-11 Unpacking of Shipping Container and Placement of Waste Package in Cell*. The residual risk from transferring wastes to storage areas following implementation of appropriate management measures is considered low.

The long-term containment of waste materials refers to when the cells are completed to final design specifications. As waste cells would be created and completed in campaigns, people would be working in the cell and in the vicinity of completed cells. The cells would be designed and constructed to meet geotechnical engineering criteria.

Ongoing management and monitoring would also be implemented with the overall objective to ensure adequate long-term stability so that it is extremely unlikely that waste materials would be exposed even over very long time periods. Landform evolution modelling of the completed containment cells has been undertaken over a period of 10,000 years suggesting minimal erosion, with contingency measures to rectify any post-completion settlement planned (Appendix A.7).

The likelihood of people being exposed to waste materials once they are stored/contained is rare. Radioactive waste materials would continue to decay and may emit gamma radiation. Given the thickness (a minimum of 7 m) of the proposed capping layer and the inclusion of compacted clay layers with a nominal permeability of 10^{-9}m/s for the containment cells, the transmission of decay products would not result in exposure risks to humans on the ground surface. This has been modelled and is presented in Appendix A.14.

In terms of chemical wastes, only solid, non-reactive, non-flammable, non-explosive materials and non-biodegradable materials would be placed in the cells. All wastes would be placed in layers with progressive backfilling to avoid the creation of voids. As a result, the waste would be stable and inert in nature and would not produce gases or liquids that are likely to migrate either vertically or horizontally from the cells.

Detailed modelling shows that there would be minimal ingress of moisture into the cells as a result of rainfall events even using extreme rainfall assumptions (Appendix A.12). As a result, there is not a completed exposure pathway for these types of wastes and as a consequence the risk to human health is insignificant even following closure of the Facility.

A complete source-pathway-receptor link is not considered credible for the storage and containment of wastes. While a source of hazard exists (that is, buried chemical and radioactive waste), a pathway to people (receptors) on the ground surface is not considered credible. Once buried under 7 m of compacted clay, laterite and silcrete, it is highly unlikely that the waste could be exposed to humans, directly or indirectly. On this basis, the residual risk to human health is considered to be low.

The acceptance and handling of waste has the potential to expose workers (through either direct or indirect contact) to waste during their work activities. Exposure resulting in adverse human health effects is considered rare when the following is taken into account:

- Waste accepted would be of a known composition and the magnitude of potential doses could be calculated with an aim to minimise exposure to be as low as reasonably practicable.
- All workers would wear appropriate PPE and would follow applicable operating procedures and safety management plans.

- Workers who load and package waste, truck drivers/transporters and emergency responders would have received training and would have experience in conducting their designated work activities including managing incidents where waste materials may be released.
- The release of waste from appropriate containment or packaging would be a very infrequently occurring incident.

On this basis, the residual risk to human health is considered to be low.

Potential for fire and loss of life

The proposed development envelope is located within the Goldfields Bushfire Region, which experiences long periods of extreme fire weather in the dry summer months (NRM Rangelands, 2015). Bushfires in this region are mostly started by lightning and while infrequent, under extreme weather conditions they can be large in scale, intense and burn all vegetation types (NRM Rangelands, 2015).

Fire and its associated smoke can affect the health or lives of people working at the Facility and may cause injury, illness or death. If a bushfire was to affect the Facility and particularly areas of temporarily stored waste (i.e. the hardstand), the potential for subsequent exposure to waste materials may increase where fire may compromise the safe packaging or integrity of the shipping containers or if an explosion occurred.

The likelihood of a bushfire affecting stored waste would be minimised by clearing vegetation surrounding the operational areas. The Radioactive Waste Warehouse and Waste Inspection Area which may temporarily store wastes would be fire rated. Fuel storage facilities and systems would be designed to meet relevant codes and access would be restricted to the Explosives Store, which would also be fire rated.

Given the management measures that would be implemented to prevent bushfires, and the additional mitigation in areas of stored waste, the risk of adverse effects to human health would be as low as reasonably practicable.

Graphical conceptual representation of the final landform

Waste material would be backfilled into cells below the land surface. A graphical conceptual representation of the final landform within the cell area once all cells have been filled and capped is provided in Figure 10-2. Post operations, the land surface would be rehabilitated. A cap of soil providing surface runoff would alter the surface profile by up to 0.5 metres higher than the current profile at the centre of the mined and backfilled cell. Surface vegetation is expected to eventually grow on the cap after a revegetation program has been implemented.

The overall change in landform is not considered significant and, therefore, would not directly impact on human health. A graphical conceptual representation of the final steps of returning the landform to near original condition after they have been backfilled are shown in Figure 10-5 and Figure 10-6.

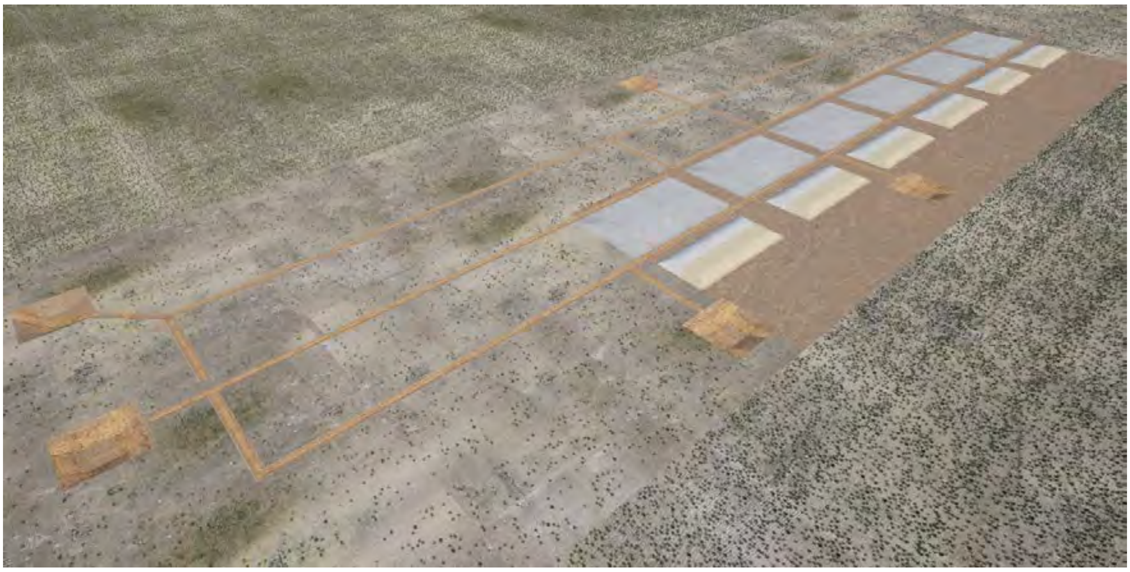


Figure 10-5 Backfilling complete capping of final cells in progress

Figure 10-6 What the landform would look like after it has been backfilled

The area would be marked by surface monuments such as those shown in Figure 10-7. Based on evolution modelling and the development of the Safety Case, the only plausible risks to human health post operations would occur in the unlikely event that a person knowingly or unknowingly disturbed the landform, for example, by digging a trench to a depth of 7 m. The effect of exposure to back filled materials on human health has been modelled at a very low risk. In addition, any potential impact would decrease with time.

Figure 10-7 Example of surface monument indicating a change in land use

Bush tucker consumption

Bush tucker foods (native plants and animals) potentially occurring within the proposed development envelope were identified through consultation with the local community and by comparison with the species list from the flora and vegetation survey and the species list of potential fauna in the development envelope identified during the fauna surveys. The bush tucker foods identified included:

- Malleefowl (*Leipoa ocellata*), considered a delicacy bush food.
- Emu (*Dromaius novaehollandiae*), used for bush food and the fat used for bush medicine.
- Echidna (*Tachyglossus aculeatus)*, considered a delicacy bush food.
- Sandalwood (*Santalum album*), used for cultural purposes (bush crafts and medicinal purposes).
- Bugadoo seeds used for bush food and medicinal purposes.
- Quandong (*Santalum acuminatum*), used for bush food.

Sandalwood and Quandong were not identified in the proposed development envelope during the flora and vegetation field survey. Malleefowl, Emu and Echidna would likely transit the proposed development envelope during the life of the Proposal. Whilst consultation did not specifically identify plants species found in the proposed development envelope, some of the plants used for bush tucker could potentially be present on the proposed development envelope.

The heritage survey did not identify sites of archaeological or ethnographic significance in the proposed development envelope. Generally, ethnographic sites of significance in the region are associated with prominent rocky outcrops or water sources, neither of which occurs in the proposed development envelope. In addition, the heritage survey made no reference to the use of the proposed development envelope for sourcing bush tucker.

Once the mine is constructed and waste accepted, the operational areas would be fenced to exclude the public, for safety reasons. The fencing would also exclude animals from the operational areas. In addition, vegetation would be cleared from the operational areas and, therefore, would not be available for consumption.

The likelihood of vegetation outside of the operational areas being affected by radiation is rare. Radioactive waste would be managed in accordance with a Radioactive Waste Management Plan which includes, storage within a restricted access building and handling procedures to minimise damage to the contents of drums (Appendix A.14). Radiation emissions modelling also predicts no impacts on vegetation (refer to the ERICA assessment in Appendix A.14). Therefore, the residual risk of bush tucker being affected by radiation is considered to be rare.

Following the completion of the cells and during the ICP, no access to the cells would be allowed. Therefore, no consumption of bush tucker would occur. Following the ICP, permanently isolated radioactive waste would have decayed to background levels and would no longer pose a human health risk, once the public are allowed to access the land.

Given that:

- There is an abundance of the same vegetation elsewhere in the region (5,773,838 ha), and therefore potentially bush tucker elsewhere in the region.
- The development envelope was/is unlikely to be used by Aboriginal people as it does not contain fresh water sources, or ethnographic sites.
- The proposed development envelope is remote from the nearest town (Koolyanobbing is 75 km away) and therefore unlikely to be frequented often by Aboriginal people specifically to consume bush tucker.
- Access to the operational areas of the Facility would be restricted during the construction and operation phase and the institutional control period.
- Accessible plants and animals (bush tucker) outside the fenced operational areas are highly unlikely to be affected by radioactivity from the waste stored on-site.
- Modelling of potential effects on plants from gamma radiation predicts no impacts would occur.

The risk to human health from bush tucker consumption would be rare.

Risks to workers at the accommodation village

The location of the proposed accommodation village has been selected against the requirements of the NHMRC guidelines. The accommodation area is in an of “zero” population density and, the projected population growth of the accommodation village will not change from what is reported in the PER. In addition, the prospects for future development at the Sandy Ridge site are also very low.

When constructed and in operation, the accommodation village is considered far enough away (3 km) from the operating site to have a neutral impact on human health. In addition, the operating management plans that are applicable to humans working at the site will maintain a neutral level of risk to the inhabitants at the accommodation village.

10.6.4 Proposed mitigation and management measures

The contents within the Outline Operating Strategy (Appendix A.16), the waste acceptance criteria documents (Appendix A.24) and the Outline safety case (Appendix A.15) aim to safeguard human health during operation of the proposed Facility. They include an assessment of construction and operational risks, safeguards around waste packaging; testing of the waste; acceptance of the waste for permanent isolation. These and other human health management measures are discussed below.

Outline Safety Case

An *Outline Safety Case* (Appendix A.15) has been prepared for the Proposal. The document is a collection of arguments and evidence in support of the safety of a facility or the activities to be undertaken at a facility. The Outline Safety Case includes the findings of the proponent's risk assessment and would include a safety assessment, a statement of risks and management measures, which is an ARPANSA regulatory requirement.

For a disposal facility, the safety case may relate to a given stage of development. The Proposal is at pre-development and as such, an *Outline Safety Case* presents potential risks and hazards and conceptually discusses their required management (refer to Chapters 6 and 7 in Appendix A.15). As the Proposal progresses into future development stages, the *Outline Safety Case* would be developed into a *Detailed Safety Case*, as required by ARPANSA.

The primary mechanism to protect human health during construction and operation is the identification of risks that may occur. These risks have been identified in the outline safety case and, subject to approval, would be developed during detailed design of the Proposal and supported by a *Detailed Safety Case*.

In addition to a fundamental analysis of the site characteristics and management practices, the Safety Case draws on best practice examples developed around the world for the safe storage and isolation of various types of hazardous wastes based on strict acceptance criteria, and for the construction in near surface geological settings that are internationally recognised as suitable.

The Safety Case is a living document which would be updated at each step of the development of the Facility – during detailed design, construction, operation and after closure.

The objective for the Safety Case is underpinned by the existing safety management system adopted by the proponent which is focused on its current business activities. These are mineral exploration, contract negotiation and approvals. Safety and management measures would be triggered following an incident under any one of the above business activities.

The safety management system described here would be revised as the proponent expands its business operations into construction and operation of the Sandy Ridge facility.

The proponent operates integrated quality, environmental management and health and safety management systems in accordance with the relevant standards:

- • ISO 9001 Quality management systems.
- • ISO 14001 Environmental management systems.
- • AS/NZS 4801 Occupational health and safety management systems.

Revisions of the safety management system would include the matters identified in Regulation 49 of the ARPANS Regulations and Regulation 558 and Schedule 17 of the WA WHS Regulations.

Outline Operating Strategy

The Outline Operating Strategy for the Proposal is provided in Appendix A.16. It provides details of how waste would be handled, stored, monitored and transported in accordance with the NEPM (as amended) and the Environmental Protection (Controlled waste) Regulations 2004 and Radiation Safety (Transport of Radioactive Substances) Regulations 2002 (WA).

The objective for the operating strategy is to control risks identified in this PER which includes some wastes that would not be acceptable for the Proposal. Solid and liquid chemical waste which would not be accepted are provided inTable 1-2 and Table 1-3 and in the WAC (Appendix A.24).

Low level radioactive waste must meet the following criteria in order to be accepted at the proposed Sandy Ridge Facility:

- Only LLW and some ILW that meet the waste acceptance criteria would be accepted for disposal. Refer to Radioactive Waste Acceptance Guide (Hygiea Consulting, 2016) for waste acceptance criteria.

If wastes in the list above can be treated and conditioned to remove the characteristics which make them unacceptable for storage in the geological repository, then they may be considered for acceptance on a case by case basis.

A range of management plans and procedures would be implemented to manage the potential impacts on human health during construction and operation of the Proposal. These management plans and operating procedures are listed in Table 10-15.

Table 10-15 Operating strategy management plans and operating procedures

Management plans	
SRMP-01	Radiation Waste Management Plan
SRMP-02	Mine Closure Plan
SRMP-03	Waste Facility Decommissioning and Closure Plan
SRMP-04	Emergency Management and Response Plan
SRMP-05	Project Management Plan
SRMP-06	Class II Landfill Post Closure Management Plan
SRMP-07	Drinking Water Quality Management Plan
SRMP-08	Radioactive Waste Acceptance Guide
SRMP-09	Construction Environmental Management Plan
SRMP-10	Operation Environmental Management Plan
Operating procedures	
SROP-01	Waste Acceptance Policy
SROP-02	Waste Acceptance Criteria
SROP-03	Waste Acceptance Procedure
SROP-04	Waste Zoning Guide
SROP-05	Assessment of Waste Pro forma
SROP-06	Review of Waste Documentation
SROP-07	External Shipping Container Audit
SROP-08	Gamma Radiation Monitoring
SROP-09	Transport Risk Assessment
SROP-10	Spill Clean-up
SROP-11	Internal Shipping Container Audit
SROP-12	Sampling of Wastes
SROP-13	Damaged and Leaking Waste Package
SROP-14	Issuing Waste Acceptance Certificate
SROP-15	Unpacking of Shipping Container and Placement of Waste Package in Cell
SROP-16	Backfilling
SROP-17	Subsidence Monitoring
SROP-18	Radon Monitoring
SROP-19	Occupational Radiation Monitoring

Waste Acceptance Criteria and supporting documents

The details and objectives of proposed WAC management measures are summarised in Section 5.5.4 and detailed in Appendix A.24.

Radioactive Waste Acceptance Guide

Acceptance criteria for radioactive waste developed for the Facility is described in the WAC (document reference THWACG170516 contained in Appendix A.14 of the PER).

The radionuclide concentration limits are set taking into account the actual siting, design and planning of the facility (e.g. Natural geological barrier, arid climate, remoteness, engineered multi-layered shielding and barriers, duration of institutional control, site specific management plans and operating procedures) and exposure dose constrains to ensure no person is exposed above the dose limit (as defined in Schedule I of the Radiation Safety (General) Regulations 1983).

Human health monitoring

Contingency measures would focus on monitoring human health. The purpose of human health monitoring would be to ensure that radiation exposure of workers remain below the statutory annual limit (1 mSv) and as low as reasonably acceptable. Triggers for exceeding the annual limit of 1 mSv may include having no radiation management controls in place, exposing works to low levels of radioactive waste for extremely long periods of time and without wearing appropriate personal protective equipment. To avoid such (unlikely) impacts on human health, the following contingency measure would be implemented through the Radiation Management Plan (RMP) provided in Appendix A.14.

Individuals working in a variety of roles would be fitted with personal monitoring devices to capture data on radiation doses received in the workplace. The monitoring would evaluate:

- Radioactive dust – personal dust samplers would collect dust particles. Samples would be analysed for gross alpha activity.
- Gamma rays – personal electronic dosimeters or Thermoluminescent Dosimeter (TLD) badges would record a worker's exposure to gamma radiation.
- Gamma radiation within specific work areas – portable TLD badges would be distributed in different works areas and used to demarcate areas based on exposure risk.

If an employee is pregnant, the employee would be issued with a personal electronic dosimeter and would be required to record her daily dose received. The employee's exposure would be calculated based on the dose received and the pregnancy time remaining. An employee's dose would be monitored throughout the pregnancy and she would be relocated to a less radioactive area if needed to ensure her dose received does not exceed 1 mSv over the pregnancy period.

Further information on human health monitoring is provided in the RMP (Appendix A.14).

Radiation Management Plan

The RMP for the Proposal is provided in Appendix A.14. The purpose of the RMP would be to ensure that radiation exposure of workers remain below the statutory annual limit (1 mSv) and as low as reasonably acceptable.

The proponent's outcome for the RMP is to eliminate and reduce, as far as possible, risks of exposure to radiation. To achieve this outcome, the proponent would take into account the following:

- Site (environmental) conditions.
- Current technological knowledge.
- Safe working conditions and whether these are being compromised by introducing a control method.
- Social and economic consequences.

The RMP would adopt the following hierarchy of control measures:

- Eliminate the hazard.
- Appropriate cell and warehouse design.
- Ventilation.
- Packaging.
- Substitute a work process for a process in which exposure levels are decreased.
- Implement engineering controls (specifically in the design and ventilation of the operational areas and the packaging of waste materials) which would prevent or reduce contact between the hazard and workers.
- Apply administrative controls such as placarding, time restrictions, work procedures and training.
- Require workers to use PPE such as respirators. Respiratory protective devices would be permanently available in the workplace. Instruction, training, proper maintenance and efficient use of the respirators would be carried out on an ongoing basis.

The radioactive disposal shaft has been designed and would be constructed in segments so that the placement of chemical waste and pre-fabricated shaft segments would progress to several metres of depth before radioactive waste placement occurs, so as to provide vertical physical separation between the radioactive waste and workers on the active surface.

The higher activity LLW would be placed at the bottom of the shaft to increase the distance between it and the surface and to reduce the exposure risk of those workers operating on the ground surface. This would reduce the exposure time, increase the distance between the radioactive waste and workers and would provide shielding between the waste and potential receptors.

Potential exposure to gamma radiation from radiation gauges would be minimised by setting those sources in concrete and then inside steel drums. This would provide shielding and would reduce the risk of exposure.

The radioactive waste warehouse would be designed and built to provide shielding and to reduce the risk of exposure. It would also be demarcated and access controlled to prevent unauthorised entry and exposure. If NORM are stored within the Radioactive Waste Warehouse, ventilation systems would be installed to minimise radon gas build-up to ensure the risk is reduced to as low as reasonable acceptable.

If there are stockpiles stored on site and material can be spread by wind the following practices would be implemented:

- Ad Hoc stockpile would be designed with a concrete slab and bunding. It can also be closed off with tarp or mesh material to ensure no generation of dust.
- Maintaining a minimum open air stock level to minimise drying and dust generation.

- A watering system and wind breaks to prevent the generation of dust.
- Shade cloth mesh barriers can be used in areas best suited to their application to prevent the generation of dust ad form wind breaks if needed.
- A dust suppression agent can be applied to non-active stockpiles to prevent dust emissions
- leaving the premises during periods of high winds; and
- A Comprehensive dust monitoring program, consisting of both personal and environmental dust monitoring, are in place to monitor and report on the efficiency of the existing control measures.

Contamination control would involve the following objectives and management measures:

- The site boundary is screened at least annually to confirm the efficiency of controls in place to prevent contamination of neighboring properties.
- All equipment that may be contaminated with radioactive material is screened to ensure they are within the release limits.
- Surface radiation contamination on plant and equipment must be less than 0.4 Bq/cm2 averaged over 300 cm^2, otherwise plant and equipment is not released from site.

To ensure ALARA principles are maintained, classification of areas is done based on the potential annual radiation exposure in excess of the natural background and the following work rules apply to those areas:

- "Radiation supervised area": an area to which access by members of the public should be minimised and restricted. General awareness of elevated radiation levels in the area is required both for employees and for visitors. Visitors to the site must be accompanied at all times.
- "Radiation Controlled area": an area to which access by employees should be limited or minimised:
- Only employees who have attended radiation safety training are allowed to work in these areas. Employees who have not attended this training are allowed to work only in exceptional circumstances.
- "Radiation restricted area" is an area where the potential for the radiation exposure of employees is above 75% of the annual dose limit. Only employees who have attended radiation safety training are allowed to work in these areas and wearing of a personal radiation monitor (a TLD badge or an electronic dosimeter) is mandatory.
- Visitors or employees who have not attended radiation safety training are not permitted to enter these areas under any circumstances except in emergency situations.

Emergency procedures would be developed to prepare for accidental spillage while transporting sources, fires and other relevant emergency situations.

Respiratory protective devices would be permanently available in the workplace. Instruction, training, proper maintenance and efficient use of the respirators would be carried out on an ongoing basis throughout the year so as to ensure the coverage of all new employees.

All employees are made aware during site induction of the risk of radiation exposure. They are made aware of the increased risk to radiation exposure if personal hygiene is not followed before eating, drinking or smoking.

Ablutions facilities are made available on site to enable employees to follow good personal hygiene practices. Designated employees dosage is monitored and calculated quarterly while pregnant employees dosage is calculated weekly. If an employee reaches 50 % of the annual exposure dose limitation, they would be removed to a non-designated area to ensure they are not being overexposed.

Monitoring of these employees would continue to ensure no overexposure to radiation. If 75 % of the annual dose limitation is reached the employee would be sent on leave or moved to activities where there are low radiation exposure levels to ensure they are not over exposed. The levels by which jobs would be rotated are given in Table 10-16:

Table 10-16 Job rotation levels

Exposure level	Pregnant employee (mSv)	Designated employee (MSv)	Contingency action
50% of dose limitation	0.5	10	Rotate employee to work in non0designated or lower radiation area.
75% of dose limitation	0.75	15	Employee to be sent on leave to prevent over exposure.

Wastewater management

The outcome objective for this management measure is to safeguard humans against the risk of contaminated waters which may result as a result of human or engineering error.

To safeguard human health, wastewater from the accommodation camp and infrastructure area (e.g. offices) would be pumped to a sewerage treatment system that would be located in the accommodation village and in the infrastructure area. Wastewater would be treated by BioMAX® systems, or equivalent. Treated effluent would be sprayed across a portion of the proposed development envelope dedicated for this purpose.

The wastewater treatment system would be designed to meet the wastewater requirements of the Shire of Coolgardie. Wastewater is not proposed to be reused.

Management of asbestiform materials

The outcome objective for this management measure is to safeguard humans against the risk of contamination from asbestiform materials.

Asbestos is not expected to be encountered within the surficial soils of the development envelope given it is relatively undisturbed (except for exploration activities), has limited access, is remote and is highly unlikely to have been used for other anthropogenic purposes. Further, metamorphic formations which may contain asbestos or asbestiform minerals were not encountered during exploratory drilling of the proposed development envelope.

Management of asbestiform materials would be focused on any incoming waste loads identified as asbestos through the waste acceptance process. The following contingencies would be adopted for the Proposal.

When carrying out licensed asbestos removal work at a waste producing site, a licensed asbestos remover must ensure that asbestos waste is contained and labelled before the waste is removed from the asbestos removal area. It must be disposed of as soon as is practicable at a site authorised to accept asbestos waste.

Asbestos-contaminated soil comprises non-attached pieces of asbestos cement products and other material containing asbestos uncovered in soil during other work activities. Contamination can be detected during building and road construction and excavation, waste disposal, damage following a severe weather event such as a hail storm, weathering over time, or when asbestos is poorly handled or damaged during removal jobs.

Individual components and wiping rags would be placed in plastic bags, tying each bag separately prior to placing them in a transport container. Disposal bags would to be heavy duty (200 µm), made of clear plastic and marked with the label 'Caution Asbestos – Do not open or damage bag. Do not inhale dust'. Asbestos waste awaiting disposal would be stored in closed containers (for example, 60 or 200 litre steel drums with removable lids or sealed skip).

A risk assessment by an independent licensed asbestos assessor or competent person, including contaminated site assessment practitioners, would determine the most appropriate control measures and remediation strategies. All asbestos and any contaminated soil removed would be disposed of as asbestos waste at a licensed waste disposal facility such as Sandy Ridge.

As a result of the pre-disposal management practices carried out at the site of waste arising, any asbestos waste arriving at Sandy Ridge would be appropriately prepared or packaged to ensure that asbestos fibres cannot become airborne at Sandy Ridge. These packaging requirements, which are the principle control mechanism to prevent airborne fibres being generated and inhaled, would be incorporated into site specific waste packaging acceptance criteria for asbestos containing wastes.

Following waste acceptance, asbestos containing material would be placed in the appropriate disposal zone and covered with a layer of kaolin during (or no later than the end of) the operating shift in which the material is emplaced. The kaolin layer provides a barrier against any further potential release of airborne fibres.

If asbestos is released and receptors are exposed, the potential dose is likely to be very low, that is below the occupational standard of 0.1 fibres/mL in air. Management of exposure to asbestos following an incident would, therefore, focus on:

- Limiting the potential for airborne asbestos fibres to be generated through stabilisation and dust control measures such as wetting.
- Limiting potential for airborne asbestos to be inhaled by ensuring only people who need be in the vicinity are, and they are protected with suitable PPE including respiratory protection.
- Appropriate decontamination and disposal of PPE which may have become contaminated during clean-up operations.

Food and water preparation

The outcome objective for this management measure is to safeguard humans against the risk of food contamination. To achieve this outcome, the following contingency measures would be adopted.

Food would primarily be prepared in the accommodation camp kitchen by experienced chefs familiar with the requirements of the *Food Act 2008* and the Food Regulations 2009. The kitchen would meet the requirements of the *Australia New Zealand Food Standards Code* (Food Standards Australia and New Zealand, 2015).

Potable water brought into the Facility or created from the reverse osmosis plant would be routinely tested to ensure compliance with the requirements for drinking water quality as outlined in the *Australian Drinking Water Guidelines* (NHMRC, 2011 as amended 2016) before it is available to workers for consumption. A Drinking Water Quality Management Plan is included in Appendix A.20 and includes a drinking water monitoring program as per the Small Community Sampling Grid and a system of compliance and reporting protocols as per the *Systems Compliance and Routine Reporting Requirements for Minesites and Exploration Camps* (Department of Health, 2011b).

Water management plan

The water quality monitoring plan is outlined in Table 4–1 of Appendix A.20. It has been prepared in accordance with the DoH's *Small Community Model Assessable Sampling Grid*. Disinfection would be through RO filtration and Chlorination.

Sample points are defined as follows:

- Source water – Carine Iron Ore Mine Pit.
- Treated water – A sample taken from the chlorination dosing system immediately after treatment.
- Distribution point – Samples taken from the pump following the storage tanks at each storage tank location (i.e. potable water tank and camp potable water tank).

- Consumer sample point – A sample would be taken at all distribution areas (i.e. the kitchen, accommodation camp and administration/production facilities).

All reporting (emergency and routine) would be conducted in accordance with Systems Compliance and Routine Reporting Requirements for Minesites And Exploration Camps (DoH, 2011). Appendix A.2 provides a risk model reporting format to be used for submission to the DoH.

Trigger and contingency actions

Human health incidents would be managed in accordance with the conceptual emergency response flow chart in Appendix A.22.

The potential impacts on human health discussed in Section 10.6.3 are considered to be low, the mitigation and management measures provided in the above documents would be implemented to further decrease risks on human health during construction and operation of the Proposal.

10.6.5 Predicted environmental outcome

Activities or situations considered to pose the greatest potential risk for adverse human health effects include kaolin mining, the acceptance and handling of hazardous and intractable waste, the storage and containment of hazardous and intractable waste, and bushfire.

Mitigation and management measures would be implemented to reduce human health impacts during both construction and operation of the Facility. The provision of multiple barriers of containment around waste, knowledge of waste content, training and supervision of all employees, appropriate PPE, monitoring of worker health and the continued improvement of waste handling and storage procedures would minimise the risk of adverse impacts on human health to as low as reasonably achievable.

With the implementation of the mitigation and management measures outlined above, the EPA's objective to ensure that human health is not adversely affected would be achieved.

10.7 Heritage

10.7.1 Introduction

This section assesses the potential impacts on heritage during both construction and operation of the Proposal. Mitigation and management measures are identified to avoid or reduce potential impacts with the objective *to 'ensure that historical and cultural associations, and natural heritage, are not adversely affected'* in accordance with the EPA's Environmental Assessment Guideline No. 8 (2015a).

This section draws on the *Report on an Aboriginal Heritage Survey of Tellus Sandy Ridge Project* (John Cecchi Heritage Management Consultancy, 2015 see Appendix A.13). The results of this study informed the assessment of the potential impacts on cultural heritage. The assessment has also been prepared with reference to the applicable standards, guidelines and procedures listed in

Chapter 4, Table 4-3 and in accordance with the requirements set out in the ESD which is presented in Appendix A.1.

10.7.2 Methodology

An Aboriginal cultural heritage assessment was undertaken with representatives of the Kapam Native Title Group, Kelamaia Kabu(d)n and Widji Group within the entire development envelope of the proposed Sandy Ridge site to assess the heritage values of the proposed development envelope and to identify the potential presence of cultural heritage items within the proposed development envelope. The cultural heritage investigation included:

- A desktop review of previous heritage surveys and relevant heritage databases to determine whether there are any listed heritage sites within or in close proximity of the proposed development envelope.
- A field survey consisting of pedestrian transects in consultation with representatives of the Kapam Native Title Group, Kelamaia Kabu(d)n and Widji Group.

The assessment of European heritage included a desktop review of publicly available information and a review of relevant heritage databases to determine whether there are any listed heritage sites within or in close proximity to the proposed development envelope.

The actual area surveyed was all the 'Development Envelope', walking north-south transects spaced 50 metres apart. Usually maps are drawn showing locations of transects if the area was sampled - i.e. survey of 10 ha in a 50 ha Proposal area, or when predictive sampling is undertaken in areas of high potential. This was not required at the Sandy Ridge site and full coverage of the development envelope area shown in Figure 1-3, meaning the whole area in question was surveyed.

As discussed in the specialist report (see Appendix A.13) *"the field survey was conducted via pedestrian transects aligned north-south, spaced fifty meters apart. Ground visibility was good, with an average of 50%. Given the survey methodology and ground visibility it is postulated that any sites with surface expressions would have been identified during the survey.' i.e. a theoretical complete ground coverage was achieved"*.

10.7.3 Assessment of potential impact and risk

There are no known records of heritage items (Aboriginal or European) within the proposed development envelope as confirmed via online database searches. In addition, the cultural heritage survey did not record any evidence of Aboriginal heritage sites (registered or previously unrecorded) within the proposed development envelope. There are also no relevant registered native title claimants and no determined native title holders.

The Aboriginal representatives from the Kaparn Native Group, Kelamaia Kabu(d)n and Widji Group (who assisted in the cultural heritage survey) provided no objection to the Proposal.

Based on the above information, there would be no impact on Aboriginal or European cultural heritage sites or on cultural associations within the proposed development envelope during construction or operation of the Proposal.

10.7.4 Proposed mitigation and management measures

As no heritage sites (registered or previously unrecorded) occur within the proposed development envelope, no additional mitigation measures would be required. In the event that items of potential European historical significance are encountered, work in their immediate vicinity (defined as a 10 metre radius) would stop and the Heritage Council and State Heritage Office would be contacted. Similarly, if items of Aboriginal heritage significance are identified during construction, work in their immediate vicinity would stop and the Department of Aboriginal Affairs in addition to the Kaparn Native Group, Kelamaia Kabu(d)n and Widji Group would be contacted for further advice.

If suspected skeletal remains are discovered during construction, work in their immediate vicinity would stop and the local police and the Department of Aboriginal Affairs would be notified as soon as possible to determine a course of action. Construction works in the area of the remains would not resume until the proponent receives written approval from either the police or from the Department of Aboriginal Affairs, as appropriate.

10.7.5 Predicted environmental outcome

As no heritage sites (registered or previously unrecorded) occur within the proposed development envelope, there would be no impact on cultural heritage during construction or operation of the Facility. As such, the EPA's objective to ensure that historical and cultural associations, and natural heritage, are not adversely affected would be achieved.

10.8 Offsets

10.8.1 Introduction

This section assesses the need to offset significant residual environmental impacts associated with the construction and operation of the Facility.

The assessment has also been prepared with reference to the applicable standards, guidelines and procedures listed in Chapter 4, Table 4-3. Particular reference has been made to the following polices/guidelines:

- *Environmental Offsets Policy* (Government of Western Australia, 2011).
- *Environmental Offsets Guidelines* (Government of Western Australia, 2014).

The assessment has also been prepared in accordance with the requirements set out in the ESD which is presented in Appendix A.1.

10.8.2 Assessment of significant residual impacts

Environmental offsets are actions that provide environmental benefits which counterbalance the significant residual environmental impacts or risks of a Proposal or activity (Government of Western Australia, 2014). Environmental offsets are required where the residual impacts are determined to be significant after avoidance, mitigation and rehabilitation have been pursued (Government of Western Australia, 2014).

To ensure consistency and transparency of whether offsets are required for a Proposal, the significance of residual impacts are determined through the application of a residual impact significance model (Government of Western Australia, 2014).

Significant residual impacts include those that affect rare and endangered plants and animals, areas within the formal conservation reserve system, important environmental systems and species that are protected under international agreements and areas that are already defined as being critically impacted in a cumulative context. Impacts may also be significant if, for example, they could cause plants or animals to become rare or endangered, or they affect vegetation which provides important ecological functions (Government of Western Australia, 2014).

The residual impact significance model outlines how significance is determined and when an offset is likely to be required or may be required in relation to relevant EPA environmental factors. The model identifies four levels of significance for residual impacts:

- Unacceptable impacts (those impacts which are environmentally unacceptable or where no offset can be applied to reduce the impact).
- Significant impacts requiring an offset.
- Potentially significant impact which may require an offset (determined by the decision-maker based on information provided by the proponent and expert judgement).
- Impacts which are not significant (those impacts that do not trigger the above categories are not expected to have a significant impact on the environment and, therefore, do not require an offset) (Government of Western Australia, 2014).

An assessment of the significance of the Proposal's residual impacts has been undertaken in accordance with the Environmental Offsets Guidelines (Government of Western Australia, 2014). The assessment is provided in Table 11-1.

10.8.3 Predicted Environmental Outcome

An assessment of the residual impacts on flora and vegetation and terrestrial fauna has been undertaken in accordance with the Environmental Offsets Guidelines (Government of Western Australia, 2014).

The only issue which potentially triggers a requirement for an offset relates to the clearing required within the former Jaurdi Pastoral Lease, of which 6.44 ha is located within the proposed

Conservation and Mining Reserve. As this area is only a proposed reserve at this stage and vegetation is sparse with no Threatened or Priority flora or Threatened Ecological Communities (TEC)s/Priority Ecological Communities (PECs) in the 6.44 ha area, the potential impact is not considered to be significant enough to warrant an offset.

10.9 Rehabilitation and decommissioning

10.9.1 Introduction

This section addresses the rehabilitation and decommissioning of the Proposal. Mitigation and management measures are identified to avoid or reduce potential impacts on the environment during both rehabilitation and decommissioning activities in accordance with the objectives of the EPA and DMP. The EPA's objective for rehabilitation and decommissioning is to *'ensure that premises are decommissioned and rehabilitated in an ecologically sustainable manner'* Environmental Assessment Guideline No. 8 (EPA, 2015a).

10.9.2 Methodology

A qualitative risk assessment has been undertaken for all aspects of mine and waste 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* and *HB 203:2012 (Managing Environment-Related Risk)*, using the proponent's Risk Assessment Matrix.

10.9.3 Assessment of potential impacts and risks

Potential impacts during rehabilitation and decommissioning include the subsidence of a waste cell allowing infiltration of water and the generation of leachate, topsoil degradation, erosion/gullies/deep rooted vegetation creating cracks in the clay capping allowing infiltration of water and the generation of leachate, vegetation not growing and unable to support a functioning ecosystem, fauna not returning and a functioning ecosystem is not achieved and long term impacts on terrestrial environmental quality, inland waters and human health. These potential impacts are discussed below.

Waste cell subsides allowing infiltration of water and generation of leachate

As discussed in Section 10.3.3, subsidence and instability of a waste cell could occur if backfilling and compaction activities are not undertaken in accordance with specified procedures. This may lead to the generation of a void space(s) within the cell, which could then cause slumping of the cell backfill, a change to the integrity of the cap, and may generate pathways with greater permeability for water to enter the cell. Water entering the cell could potentially generate leachate from the waste packages.

Hazards which may contribute to the subsidence are primarily related to achieving the backfill and compaction requirements of the engineering design. This would be managed through briefings to the operators from the project engineer, measurements of compaction density undertaken in accordance with *AS1289.5.8.1*, visual inspection following placement of waste and backfill of each layer, and topographical survey at the completion of each layer to confirm engineering specifications have been met and monitoring of the clay dome following cell completion.

Topsoil is degraded and unable to support a functioning ecosystem

Vegetation and topsoil would be stockpiled and later re-spread during rehabilitation and decommissioning. Topsoil would be preserved in a condition as near as possible to its pre-mining condition in order to allow for successful rehabilitation.

Procedures would be implemented to preserve topsoil during topsoil stripping and for the storage and appropriate use of topsoil during progressive cell closure and rehabilitation. Specifically, a topsoil stripping procedure would be implemented to maximise the volume of suitable topsoil removed, thereby maximising topsoil available for rehabilitation and decommissioning.

Stockpile design and maintenance procedures would be implemented as would erosion control techniques (for stockpiled topsoil and exposed subsoil following stripping and during rehabilitation). A topsoil application procedure (to be used during rehabilitation) would also be implemented. These procedures would be included in the CEMP, OEMP, WFDCP (refer Appendix A.18) and MCP (refer Appendix A.19).

Erosion/gullies/deep rooted vegetation create cracks in the clay capping which allows water to infiltrate and generate leachate from the stored waste

Current weathering and erosion in the area is extremely slow. The near horizontal sandy surface and lack of stream channels results in rain water being absorbed into this surface unit, rather than running off with resulting water erosion. Wind erosion is very limited, as the sandplain is well covered with native vegetation and average wind speeds are low for the majority of the year.

Following the placement of the final waste layer, capping layers would be used to fill the remaining void and cover the completed waste cell. This would occur at approximately 7 m below the ground surface. This capping layer serves to provide a barrier between the waste materials and the surface; to prevent water infiltration; and to prevent erosion. Landform evolution modelling predicts that after 10,000 years there is relatively little change to the clay domes and the landform is likely to be erosionally stable over the very long term (Landloch, 2016; Appendix A.7).

As discussed in Section 10.2.4, all disturbed areas would be rehabilitated in accordance with the WFDCP (refer Appendix A.18) and MCP (refer Appendix A.19). Rehabilitation would include revegetation using local indigenous species. Groundwater-dependent species would not be planted.

The vegetation planted would be adapted for semi-arid environments and, therefore, would be shallow rooted with a fibrous root system rather than a tap root system which may penetrate deeper. There would be a separation distance between the shallow plant roots and the stored waste. Approximately 7 m of compacted backfill would separate stored waste from the surface. Vegetation would be planted in the topsoil on the domed cap, which is elevated between approximately 1.7–5 m above the ground surface. It is highly unlikely plant roots would penetrate to the stored waste.

Given the above discussion, it is highly unlikely that erosion/gullies or deep rooted vegetation would create cracks in the clay capping. It is, therefore, unlikely that water would infiltrate the cells and generate leachate from the stored waste.

Vegetation does not grow and is unable to support a functioning ecosystem

As discussed in Section 10.2.4, all disturbed areas would be rehabilitated in accordance with the WFDCP (refer Appendix A.18) and MCP (refer Appendix A.19). Rehabilitation would primarily include respreading of topsoil, ripping of surface, revegetation using local indigenous species, irrigation in the initial months of establishment and the application of fertiliser (where appropriate). Further details on rehabilitation are provided in detail in Appendices A.17 and A.19.

In order for planted vegetation to survive in the rehabilitated areas, groundwater-dependent species would not be planted. The vegetation planted would be adapted for semi-arid environments and, therefore, would be shallow rooted with a fibrous root system rather than a tap root system which may penetrate deeper. There would be a separation distance between the shallow plant roots and the stored waste. Approximately 7 m of compacted backfill would separate stored waste from the surface. Vegetation would be planted in the topsoil on the domed cap, which is elevated between approximately 1.7 to 5 m above the ground surface. It is highly unlikely plant roots would penetrate to the stored waste.

No risk to flora and vegetation is foreseen with regards to radiation exposure, as demonstrated using ERICA (refer to Appendix A.14).

Based on the above, it is anticipated that all disturbed areas would be rehabilitated so as to achieve a functioning ecosystem.

Fauna does not return to the vegetation and therefore a functioning ecosystem is not achieved

As discussed above, all disturbed areas would be rehabilitated in accordance with the WFDCP (refer Appendix A.18) and MCP (refer Appendix A.19). Rehabilitation would primarily include respreading of topsoil, ripping of surface, revegetation using local indigenous species adapted for semi-arid environments (with shallow, fibrous root systems that would be highly unlikely to penetrate the stored waste), irrigation in the initial months of establishment and the application of fertiliser (where appropriate).

No risk to fauna is foreseen with regards to radiation exposure, as demonstrated using ERICA (refer to Section 10.4.3 and Appendix A.14).

It is anticipated that all disturbed areas would be rehabilitated so as to achieve a functioning ecosystem. Flora and vegetation would become established, creating habitat for local fauna.

Long-term impacts on terrestrial environmental quality, inland waters environmental quality and human health

There would no long-term impacts on terrestrial environmental quality, inland waters or to human health, as demonstrated in Section 10.3 and Section 10.5. In addition to the information presented in these sections, the outline RMP contained in Appendix A.14 provides safeguard measures to avoid, minimise and reduce any risks associated with radioactive waste.

Graphical conceptual representation of the final landform

Key findings of the landform evolution modelling report attached in Appendix A.7 are:

- 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 10-8). This is based upon a simplistic model using peaked crests and flat batter slopes. In reality, crests and swales would all be broadly rounded or smoothed landforms.

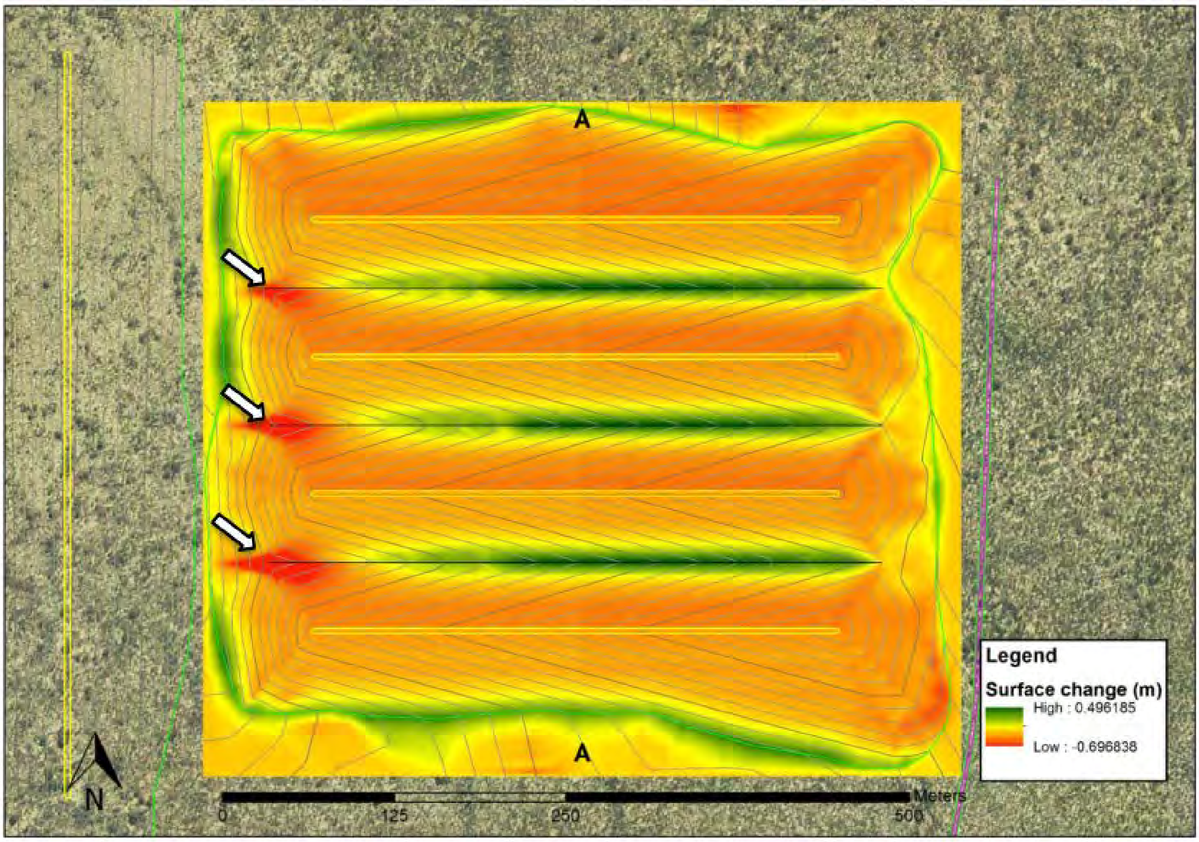


Figure 10-8 SIBERIA model 10,000 year results for long term landscape evolution of cells

The predicted original surface and the surface after 10,000 year simulation is shown in Figure 10-9 (not the axis in Figure 10-9 is shown in metres).

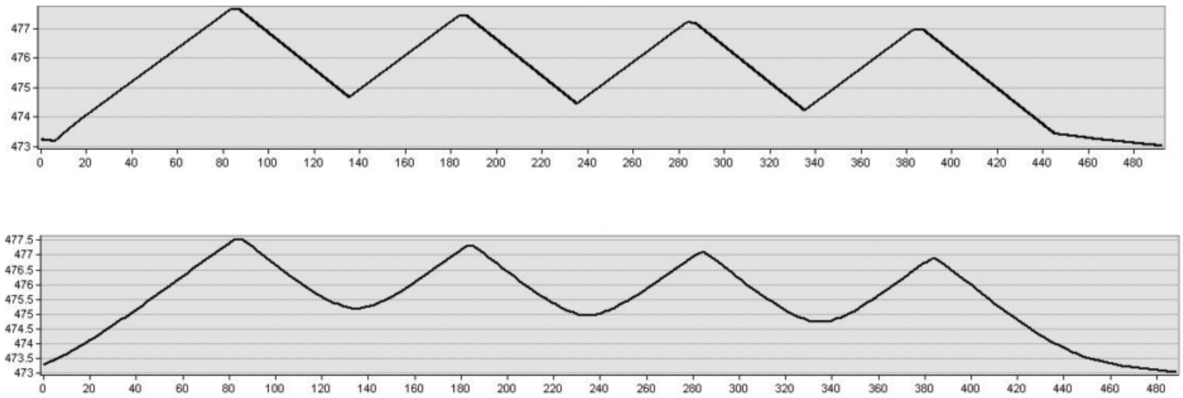


Figure 10-9 SIBERIA model results cross section for the original surface (top) and at 10,000 years (bottom)

Further discussion and graphical representation of long term landform evolution is provided in Section 10.3.3.

Other potential risks during rehabilitation and decommissioning (results of risk assessment)

The risk assessment identified six planned and 14 unplanned credible risks. The highest residual ranking risks were:

- Major earthquake with surface displacement and cracking of the domed caps over the cells. This could lead to subsidence/slumping of the cell and further erosion of the cap (rills and gullies). The loss of cell stability could potentially allow water to infiltrate into the cells, potentially generating leachate from waste packages into the surrounding clay
- Bushfire which may cause injury or death of Threatened/Priority fauna and damage revegetation
- Terrorist attack from a plane crashing into, or bombing of, the cells. This may cause an expulsion of chemical and radioactive waste from the cell to the surface and into the atmosphere
- Failure of revegetation due to degraded topsoil, compacted soils, erosion, fauna predation, lack of seed pre–treatment, no tubestock available, and weed invasion
- Unauthorised access to the Facility and/or accidental deep excavation into a cell (i.e. mineral exploration). This could impact upon human health and potentially lead to injury or death of fauna by falling into the cell. The cell may become unstable and collapse.

Additional risks have been identified and ranked as 'low' risk. The full risk assessment is provided in the WFDCP and MCP (see Appendix A.18 and A.19).

The stability of the cells is of paramount importance to the rehabilitation and decommissioning of the proposed development envelope. The potential sources of risk outlined above all have the potential to affect the stability of the cell. Any water infiltrating the cell has the potential to leach contaminants from the solid chemical and low LLW contained within the cell. The consequence may include emissions to the atmosphere which may have adverse effects on humans and flora and fauna, and may cause injury or death.

The likelihood of death of humans or flora or fauna would be reduced during the closure period as all cells would be capped and in varying states of subsidence monitoring and radiation monitoring. The risk would be further mitigated by the site continually being managed, through the ICP by the appropriate authority. 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 (see Section 5.13).

10.9.4 Proposed mitigation and management measures

The proposed management for closure of the mining aspect and the waste disposal aspect have been segregated, primarily as the regulation of mining and waste disposal are managed under different legislation in WA. Therefore, two closure and decommissioning plans would be implemented specific to each aspect of the Proposal:

- Mining aspect – details relating to mine closure for tenement relinquishment are outlined in the MCP required under the *Mining Act 1978* (WA). See Appendix A.19.
- Waste disposal aspect – details relating to the cells and residual infrastructure needed to rehabilitate the Facility post closure of the cells, is set out in the WFDCP. See Appendix A.18.

The implementation of two closure and decommissioning plans also accounts for the differing timeline for closure and decommissioning of both aspects. The MCP would be implemented during the operational phase of the Facility (Year 0 to 25). Closure and decommissioning activities would extend further until the mining tenement is relinquished (currently expected to be Year 37). Once the mining tenement is relinquished, the MCP would no longer apply or be implemented at Sandy Ridge.

The WFDCP would be implemented during the operational phase (Years 0 to 25), during the post closure management period (Years 26 to 45) and for the agreed ICP.

Decommissioning of infrastructure would occur in phases, depending on if it is used for mining/processing of ore, or for the waste facility. Decommissioning schedules are provided in both the MCP and the WFDCP. The general closure stages are:

1. Collection of baseline data.
2. Research investigation and trials.
3. Materials handling and utilisation
4. Identification of potential contamination.
5. Progressive rehabilitation.

The applicable domains, the purpose and key activities of each strategy, and a description of the strategy to be implemented is described in A.19

Both plans are considered 'living' documents, and would be reviewed and revised every three years. They also include requirements to conduct consultation with stakeholders to continually discuss closure issues and management.

The closure objectives, indicative completion criteria and key measurement tools outlined in the MCP and WFDCP are presented below.

Mine Closure Plan

The closure objectives, indicative completion criteria and the key measurement tools outlined in the MCP for the Proposal are presented in Table 10-17. Further detail is provided in Appendix A.19.

Table 10-17 Closure objectives, indicative completion criteria and key measurement tools (Mine Closure Plan)

Closure objective	Indicative completion criteria	Measurement tools
Each excavated pit is structurally stable.	At closure, the pit walls do not collapse inwards.	Geotechnical assessment.
Each excavated pit is free of ponded water (i.e. not a pit lake).	At closure the mine void does not pose a safety hazard, that persons or vehicles could accidently fall into. The mine void would not contain water of sufficient volume that could create a potential drowning hazard.	Visual inspection. Safety bunding around all open pits.
Vegetation in rehabilitated areas is comparable as reasonably practicable to the analogue site.	At the completion of the 10 year rehabilitation 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 to be introduced into the area.	Revegetation monitoring.
Mining related infrastructure (except for that infrastructure to be closed under the WFDCP) removed from site during the Decommissioning Phase.	At mine closure, no mining related infrastructure is left on the tenement.	Visual inspection.

Five domains have been developed for the purpose of mine closure planning:

1. Pits
2. Infrastructure area.
3. Accommodation camp.
4. Class II Putrescible Landfill.
5. Access roads

The water pipeline and associated infrastructure, the access roads into the mining lease, underground storage area and the cells would not be closed under the MCP; rather they would be closed under the WFDCP.

To estimate a timeline for closure, the proponent has assumed the following:

- A start date of 1 January 2018.
- That 25 mine pits would be created.
- That 10 years of vegetation monitoring of all domains would occur.
- Completion criteria would be met at year 37 of the Proposal. Based on these assumptions the timeline is shown in Table 10-18.

Table 10-18 Closure timeline

Year of the Proposal	Year 1 – 25	Year 26	Year 36	Year 37
Current estimated year	**2018 – 2042**	**2043**	**2052**	**2053**
Pits created, ore excavated				
Deep ripping/establishment of vegetation				
Vegetation monitoring				
Completion criteria met				
Mining tenement relinquished				

Vegetation monitoring during closure

The methodology appropriate for monitoring vegetation from year 26 to 36 would 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 would be part of an integrated approach designed for the specific climate of the site. The method or combination of methods would be repeatable (and auditable) and supported by studies and scientific literature. The methodology would also be discussed with the regulator prior to implementation.

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 would be setup and monitored, as per the same methodology as the rehabilitation sites. The purpose of the analogue sites would be to act as a control site, and used for comparison of monitored parameters.

Monitoring of all revegetated areas would 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.

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

Targeted remediation of poor–performing rehabilitation areas may be necessary. The proponent would 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.

Soil monitoring during closure

The *Mine rehabilitation* handbook (DTIR, 2006) confirms that a "combined use of a front-end loader, truck and bulldozer for the removal, transport, and spreading of topsoil is the best combination to reduce soil compaction.

Soils would be monitored for their physical and chemical condition to ensure any revegetation and/or rehabilitation programs undertaken are successful. Monitoring should occur at a minimum of every 12 months and should record:

- Surface condition and erosion.
- Nutrient status, pH and EC.
- Seed germination rates.

Waste Facility Decommissioning and Closure Plan

The closure objectives, indicative completion criteria and the key measurement tools outlined in the WFDCP for the Proposal are presented in Table 10-19. Further detail is provided in Appendix A.18.

Table 10-19 Closure objectives, indicative completion criteria and key measurement tools

Closure objective	Indicative completion criteria	Measurement tools
Structurally stable, non–eroding disposal cells.	No subsidence of pits over the subsidence monitoring period.	Subsidence monitoring.
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.	Erosion, radiation, and groundwater monitoring.
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.	Revegetation monitoring.

10.9.5 Predicted environmental outcome

The application of an MCP on a mining tenement is standard practice under the *Mining Act 1978*. Therefore, the kaolin mining aspect of the Proposal, with agreed closure objectives and completion criteria for rehabilitation, is fairly straightforward for this Proposal.

With the implementation of the MCP, the EPA's objective to ensure that premises are decommissioned and rehabilitated in an ecologically sustainable manner would be achieved. Three-yearly revisions of the MCP would be undertaken to ensure that rehabilitation and decommissioning is conducted in an ecologically sustainable manner at closure and that improvements in restoration and rehabilitation techniques are accommodated.

Given the closure of a Class V Waste Facility is a pioneer activity in WA (the IWDF Ministerial Statements does not include a requirement for a closure plan), the expectations for closure and decommissioning come from national guidance (ARPANSA, 2010 and NHMRC, 1992) and a review of publicly available international facilities' decommissioning and closure plans (LLW Repository Ltd, 2014 and ENRESA, 2007).

Given the three-yearly revision of the WFDCP, the discussions that would be held with stakeholders and the commitment to continual improvement and adherence to international best practice for closure of similar facilities, the EPA's objective would be achieved.

11 ASSESSMENT OF OTHER ENVIRONMENTAL FACTORS

11.1 Amenity

11.1.1 Introduction

This section assesses the potential impacts on amenity during both construction and operation of the Proposal. Mitigation and management measures are identified to avoid or reduce potential impacts with the objective *to 'ensure that impacts to amenity are reduced as low as reasonable practicable'* in accordance with the EPA's Environmental Assessment Guideline No. 8 (2015a).

The assessment has also been prepared with reference to the applicable standards, guidelines and procedures listed in Chapter 4, Table 4-3 and in accordance with the requirements set out in the ESD which is presented in Appendix A.1.

11.1.2 Methodology

The methodology for assessing impacts on amenity included a review of the potential environmental impacts documented in other sections of this chapter and a reinterpretation of these impacts from a community-focused perspective.

11.1.3 Assessment of potential impacts and risks

Impacts on amenity during construction and operation of the Proposal include noise, dust and other issues such as the visibility of the Proposal. These impacts are discussed below.

Noise emissions

Construction and operation of the Proposal would generate noise during day time hours only. Noise generated during construction would include that from earthmoving and from truck movements and the use of construction equipment and machinery. Noise generated during operation would include that from mining (e.g. blasting and processing of ore) and subsequent waste disposal activities, and from truck movements and the use of operational equipment and machinery. At night, the only noise is likely to be associated with onsite power generation, but this plant would be noise attenuated to limit occupational noise impacts.

The nearest sensitive receptor to the Proposal is the IWDF, which is located approximately 5.5 km east of the proposed development envelope (refer to Figure 1-4). The IWDF operates infrequently on a campaign style basis during day time operating hours, with the most recent operation being conducted in 2008. This site has permanent camp facilities to accommodate five personnel, however, no permanent workforce is located there. Given the distance from the proposed development envelope to the camp facilities at the IWDF, the infrequent operations at the IWDF, similar operating hours (during a campaign) to the Proposal (i.e. day time) and the low numbers of temporary workers, noise impacts are highly unlikely to impact people at the IWDF.

Other sensitive receptors located in the vicinity to the proposed development envelope include the Jaurdi Homestead (approximately 51 km away), the Carina Iron Ore Mine Accommodation Village (approximately 52 km away), and Koolyanobbing (approximately 75 km away). Given the significant distance from the proposed development envelope to these sensitive receptors, noise impacts would be negligible.

Impacts on workers at the Carina Iron Ore Mine (approximately 13 km away) and J4 Iron Ore Mine (approximately 63 km away), both of which are industrial premises, are also predicted to be negligible due to distance (refer to Figure 11-1).

Impacts from noise on workers within the onsite accommodation camp have also been considered; however, as site operations would occur during day time hours only, no impacts on workers within the accommodation camp would occur.

Dust

Concerns about amenity from dust often relate to 'visibility' of dust plumes and dust sources. Visible dust usually has a particle size larger than 10 µm and at high levels may reduce visibility and amenity. Visible dust is usually due to short-term episodes of high emissions, such as from blasting, however, other activities such as vegetation stripping, topsoil and subsoil stripping, excavation of cells, truck movements and processing may also generate visible dust. The impact of dust on local amenity mainly depends on the distance from the source to nearby receptors.

As discussed above, the nearest permanent sensitive receptors to the proposed development envelope are tourists staying at the Jaurdi Homestead (approximately 51 km away) and residents of the Carina Iron Ore Mine Accommodation Village (approximately 52 km away). Blasting would only be undertaken for a matter of seconds once per year with the other mining activities not likely to generate substantial volumes of dust due to the small area of disturbance at any one time.

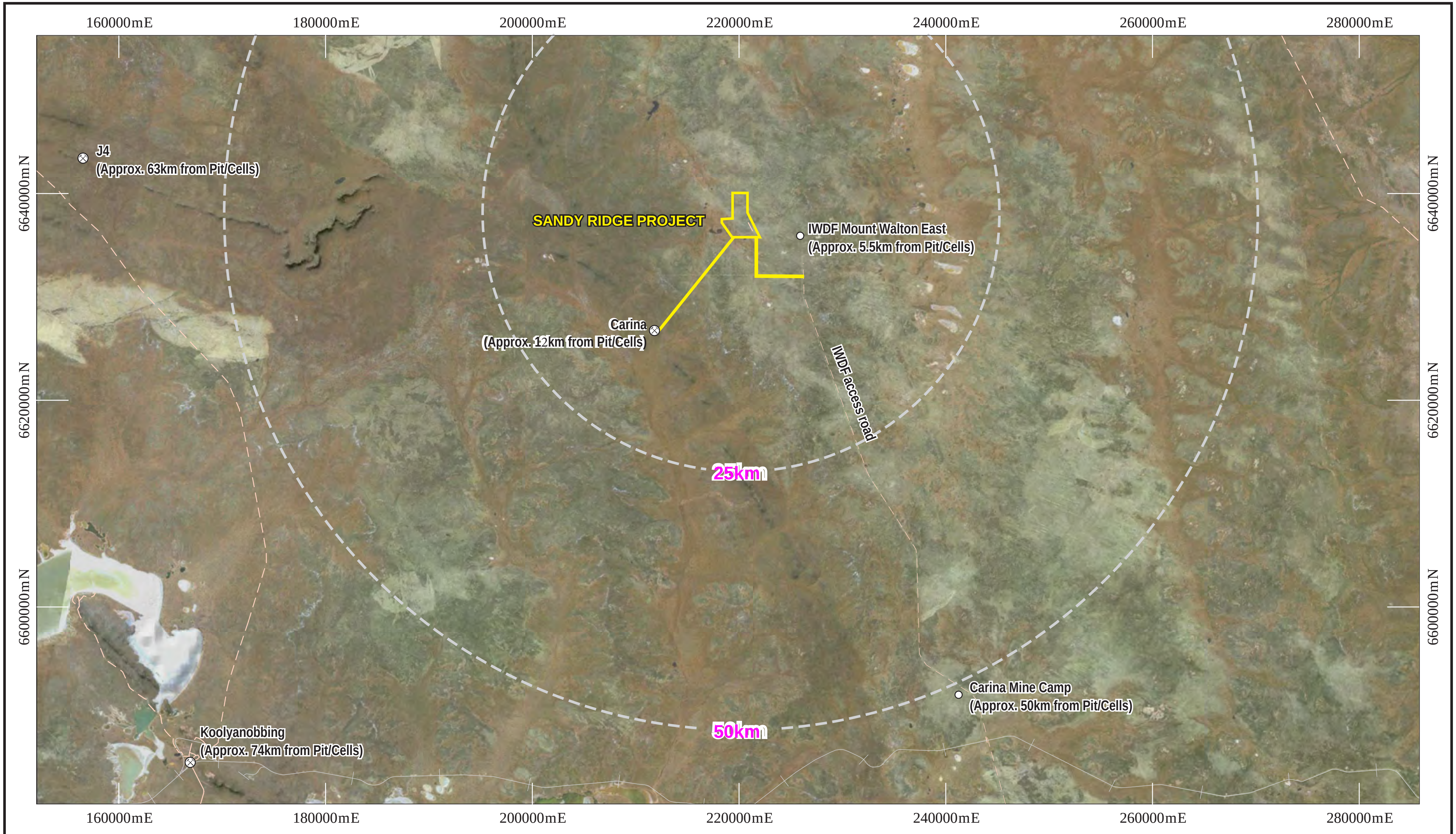
Given the distance to these receptors, the remote location of the proposed development envelope, the short timeframes for dust generation from blasting and other mining activities, and the adoption of standard dust control practices (including the processing of ore in an enclosed building), dust emissions would not reduce the amenity in the vicinity of these receptors.

Visual amenity

The impacts on the visual amenity of people (identified as tourists and scientists) using the Mount Manning Range Nature Reserve, Mount Manning – Helena and Aurora Ranges Conservation Park and the former Jaurdi Pastoral Lease have been considered in terms of travel routes/access tracks and the use of public view points. It should be noted that impacts on visual amenity are considered to be subjective with the level of perceived impact likely to vary between stakeholders.

Access would not be restricted to the Mount Manning Range Nature Reserve, Mount Manning – Helena and Aurora Ranges Conservation Park or the former Jaurdi Pastoral Lease. Access to these areas is primarily made via Koolyanobbing, approximately 75 km south-west of the proposed development envelope.

The Proposal would also not be visible from the nearest boundary of the Mount Manning Range Nature Reserve, Mount Manning – Helena and Aurora Ranges Conservation Park or the former Jaurdi Pastoral Lease. It would also not be visible from the public viewpoint located at the highest point of the Mount Manning – Helena and Aurora Ranges Conservation Park. Photo simulations reflecting the viewpoints from each of these locations have been generated and are shown in Figure 11-2 to Figure 11-5.



Legend:
Iron Ore Mine
Development Envelope
Rail
Major Road
Minor Road

TELLUS

N

0 10km
Scale 1:500,000
MGA94 (Zone 51)
CAD Ref: g2294_PER_09_08.dgn
Date: Nov 2016 | Rev: C | 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 Facility

Nearest receptors

Public Environmental Review

Figure:

11-1

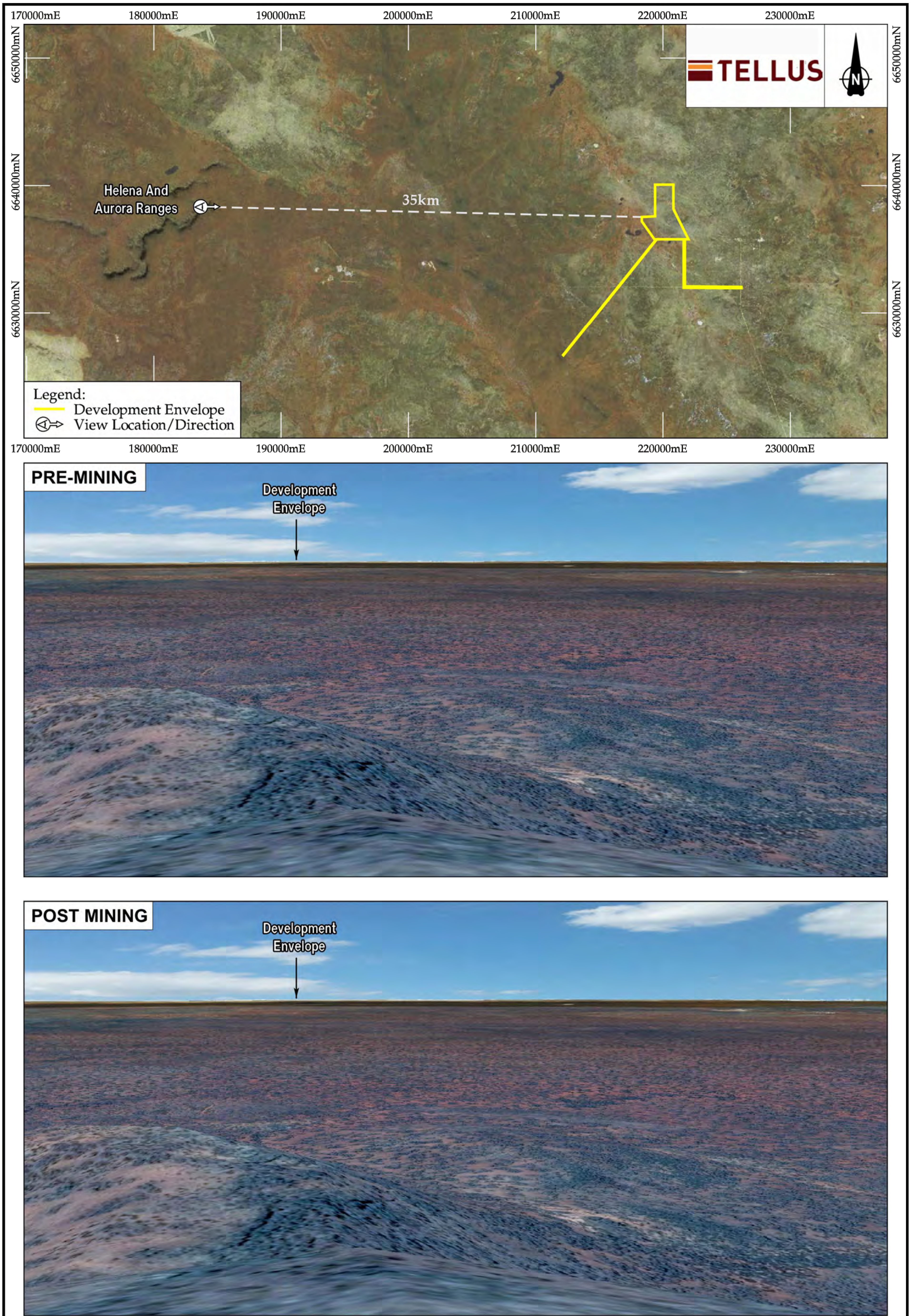
11.1.4 Proposed mitigation and management measures

Although there would be no reduction in amenity as a result of noise, dust or visual impacts, the following mitigation and management measures would be implemented during construction and operation of the Proposal:

- Dust suppression and management measures would be implemented to minimise dust impacts where possible. This would include:
  - Application of dust suppression methods along internal access roads and hard stand areas using watercarts during dry, dusty periods.
  - Weather conditions would be monitored prior to mining activities most likely to generate dust (i.e. vegetation removal, topsoil and subsoil stripping, and blasting).
  - Dust deposition gauges would be installed on the proposed development envelope boundaries nearest to the IWDF and the former Jaurdi Pastoral Lease and monitored quarterly for the initial 12 months. The final locations of dust deposition gauges would be identified in consultation with the DER.
- Best practice noise management would be implemented during operation of the mine to ensure compliance is achieved with the Environmental Protection (Noise) Regulations 1997.
- Disposal cells would be rehabilitated on completion of subsidence monitoring with the objective of producing a surface slightly mounded above the existing natural surface that is vegetated.
- Following closure of the mine, all mining related infrastructure would be removed and disturbed areas would be rehabilitated.

11.1.5 Predicted environmental outcome

There would be no reduction in amenity as a result of noise or dust within the local area, or impacts on visual amenity for people using the Mount Manning Range Nature Reserve, Mount Manning – Helena and Aurora Ranges Conservation Park or the former Jaurdi Pastoral Lease. Mitigation and management measures would also further reduce amenity impacts (e.g. best practice noise and dust suppression mitigation measures and rehabilitation of the proposed development envelope upon closure). As such, the EPA's objective to ensure that impacts on amenity are reduced as low as reasonable practicable would be achieved.



0 5km

Scale 1:400,000
MGA94 (Zone 51)
CAD Ref: g2294_PER_09_06.dgn
Date: November 2016 Rev: B A4

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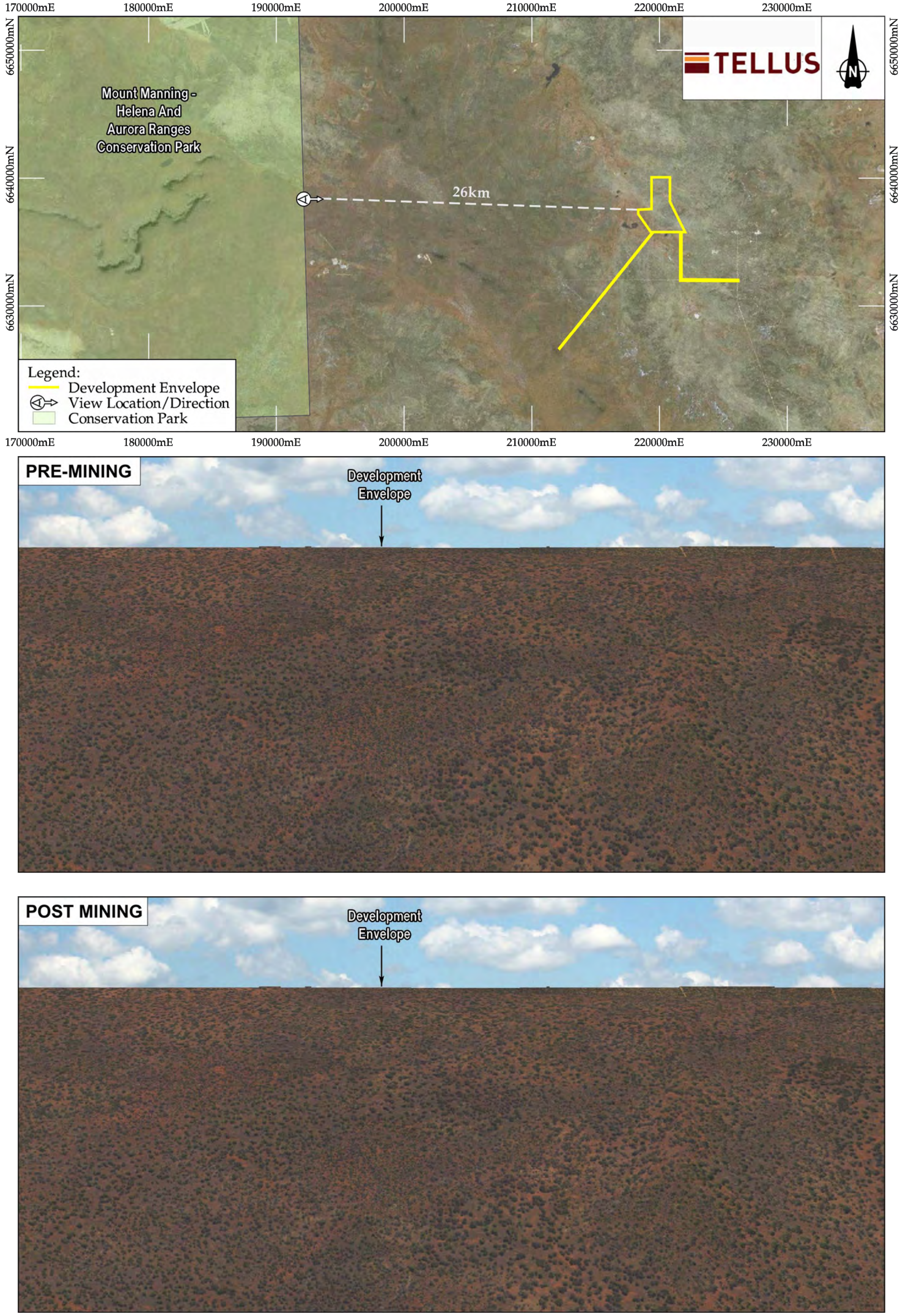
Sandy Ridge Facility
Top of Helena and Aurora Ranges Conservation Park
Public Environmental Review

Figure:
11-2



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Scale 1:400,000
MGA94 (Zone 51)
CAD Ref: g2294_PER_09_07.dgn
Date: November 2016 | Rev: B | A4

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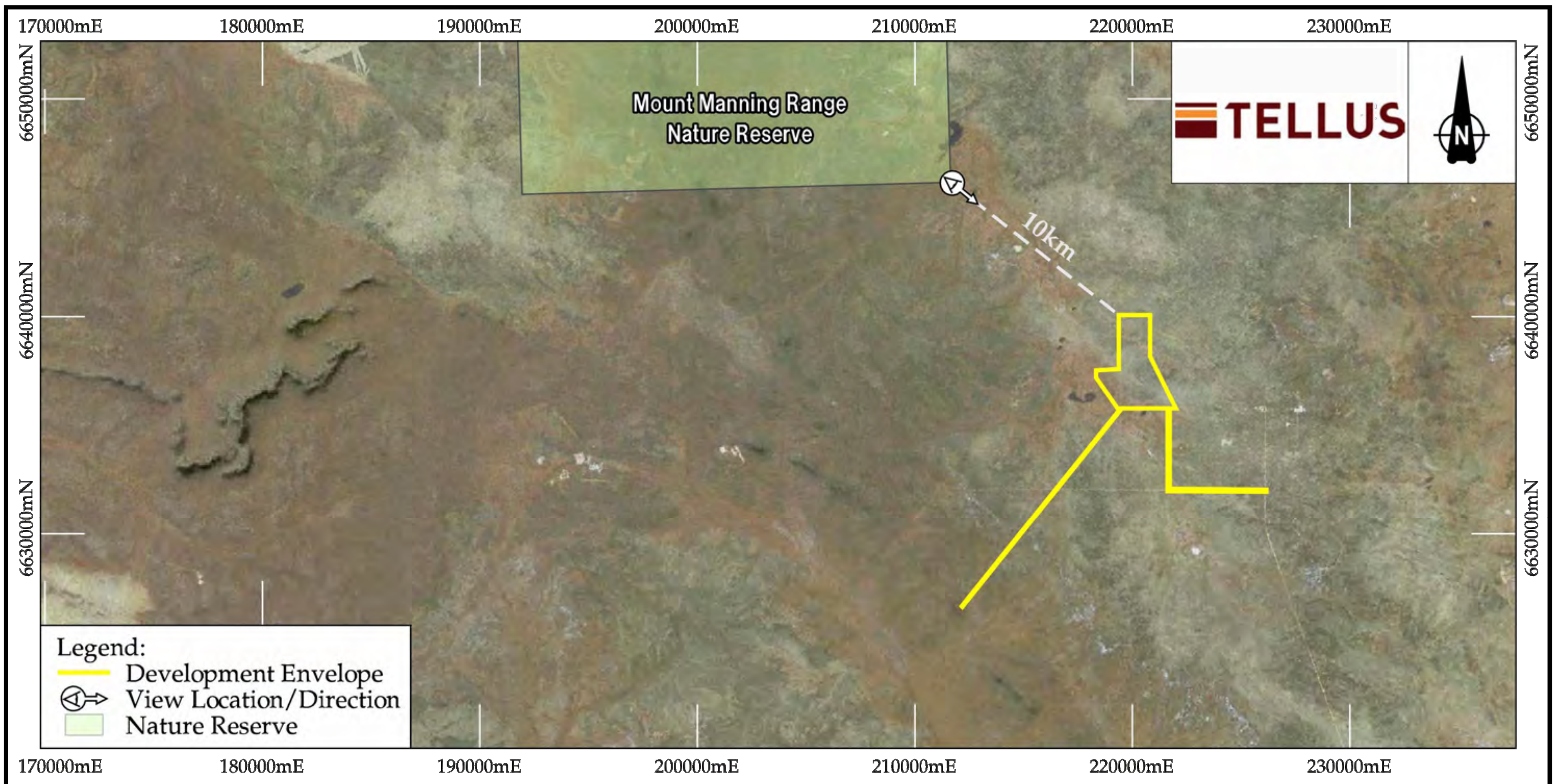
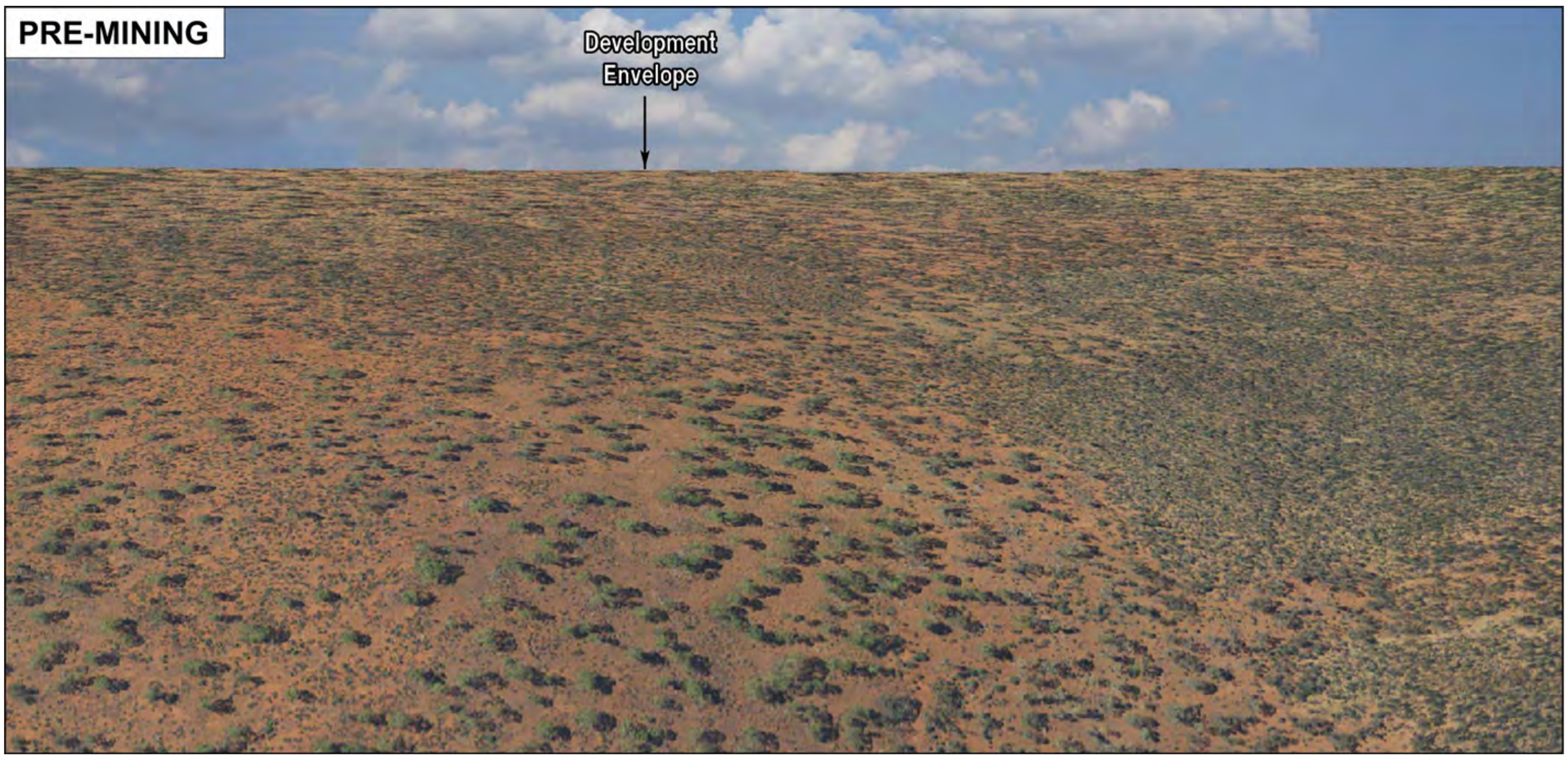
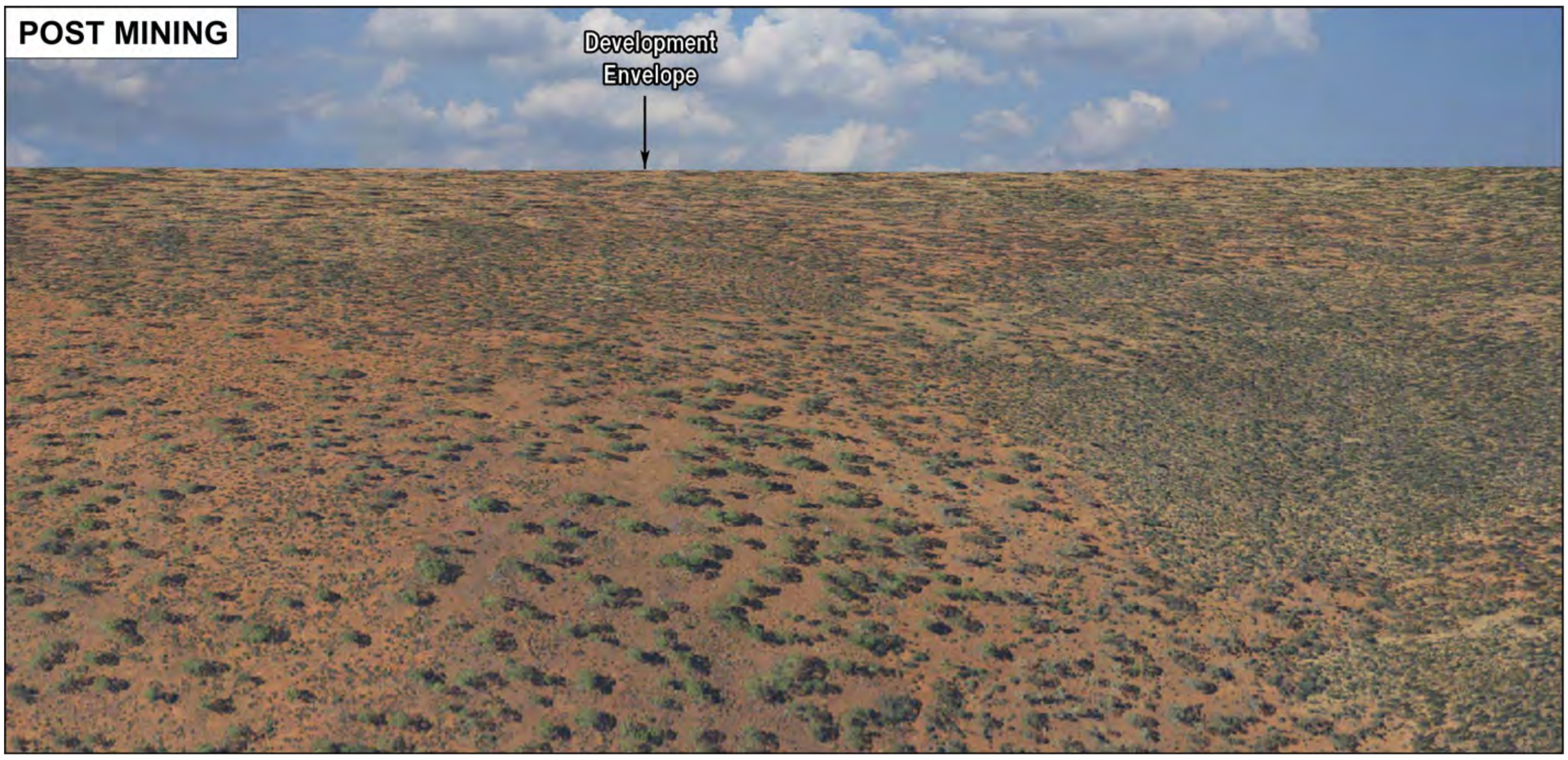
Sandy Ridge Facility
Top of Mount Manning - Helena and Aurora Ranges Conservation Park
Public Environmental Review

Figure:
11-3







0 5km Scale 1:400,000 MGA94 (Zone 51)	Aurora environmental	Sandy Ridge Facility **Mount Manning Range** **National Reserve** Public Environmental Review	Figure: **11-4**
CAD Ref: g2294_PER_09_08.dgn	Author: C. Dorrington | AE Ref: THO2014-003		
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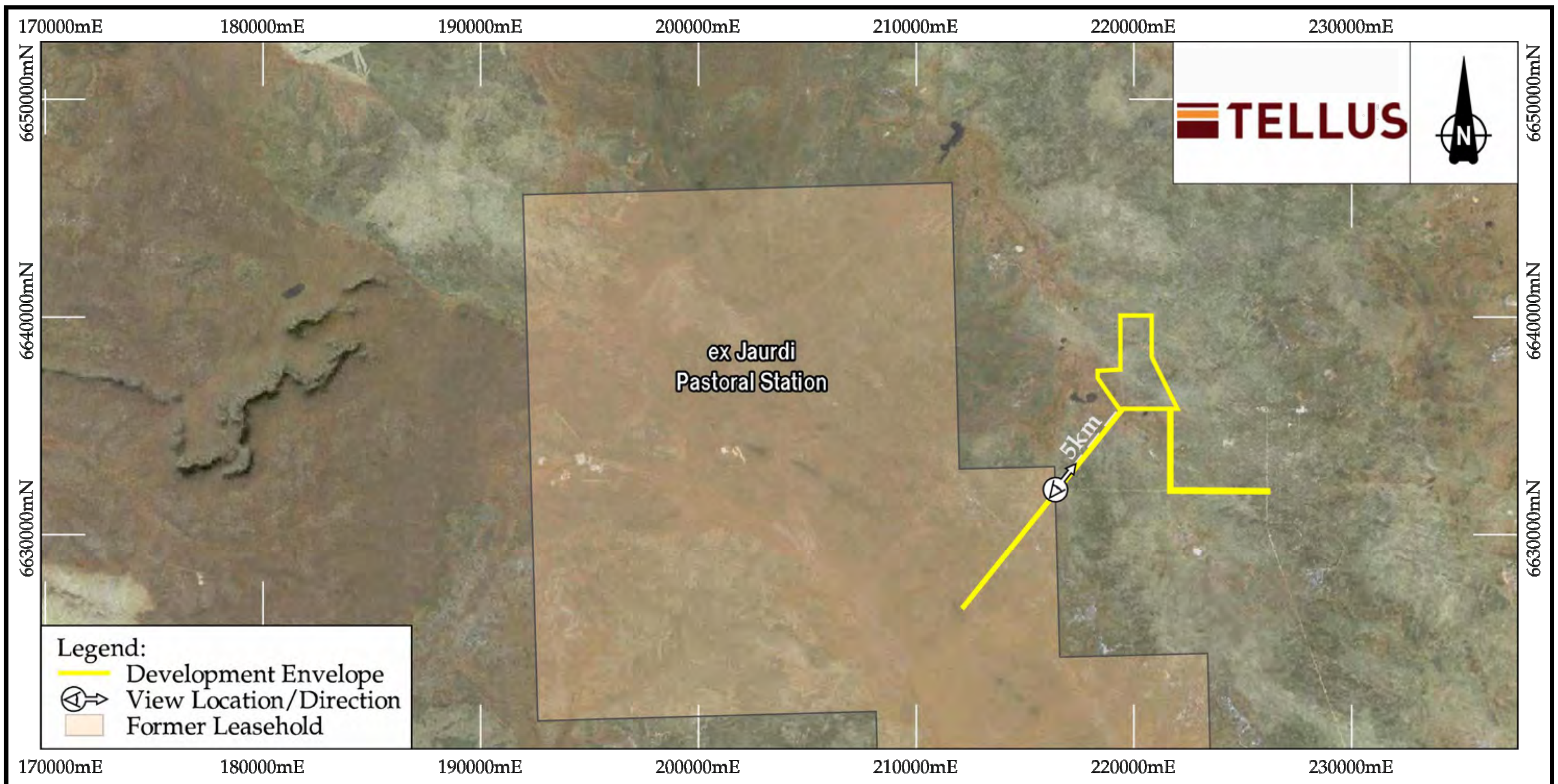

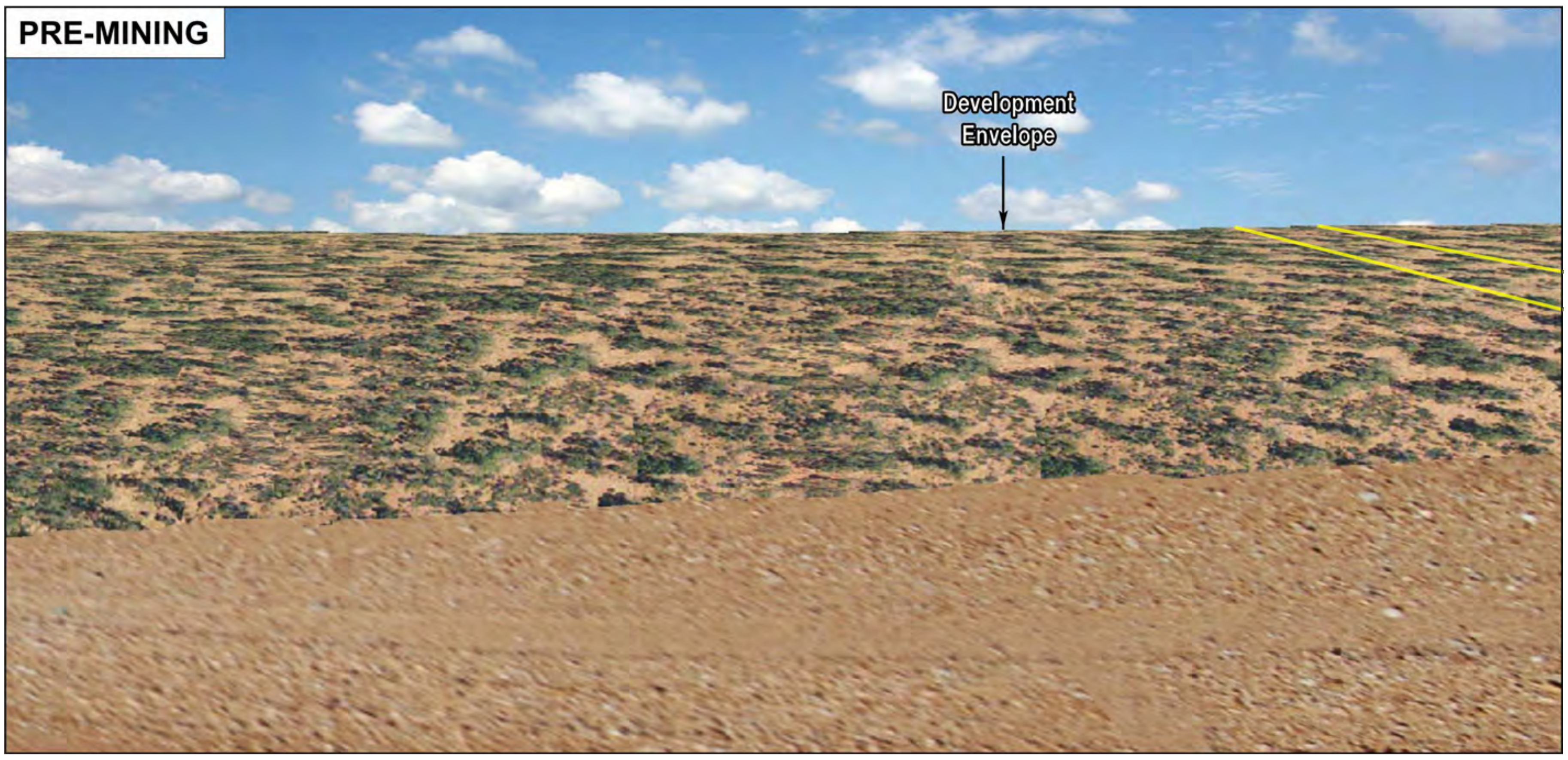

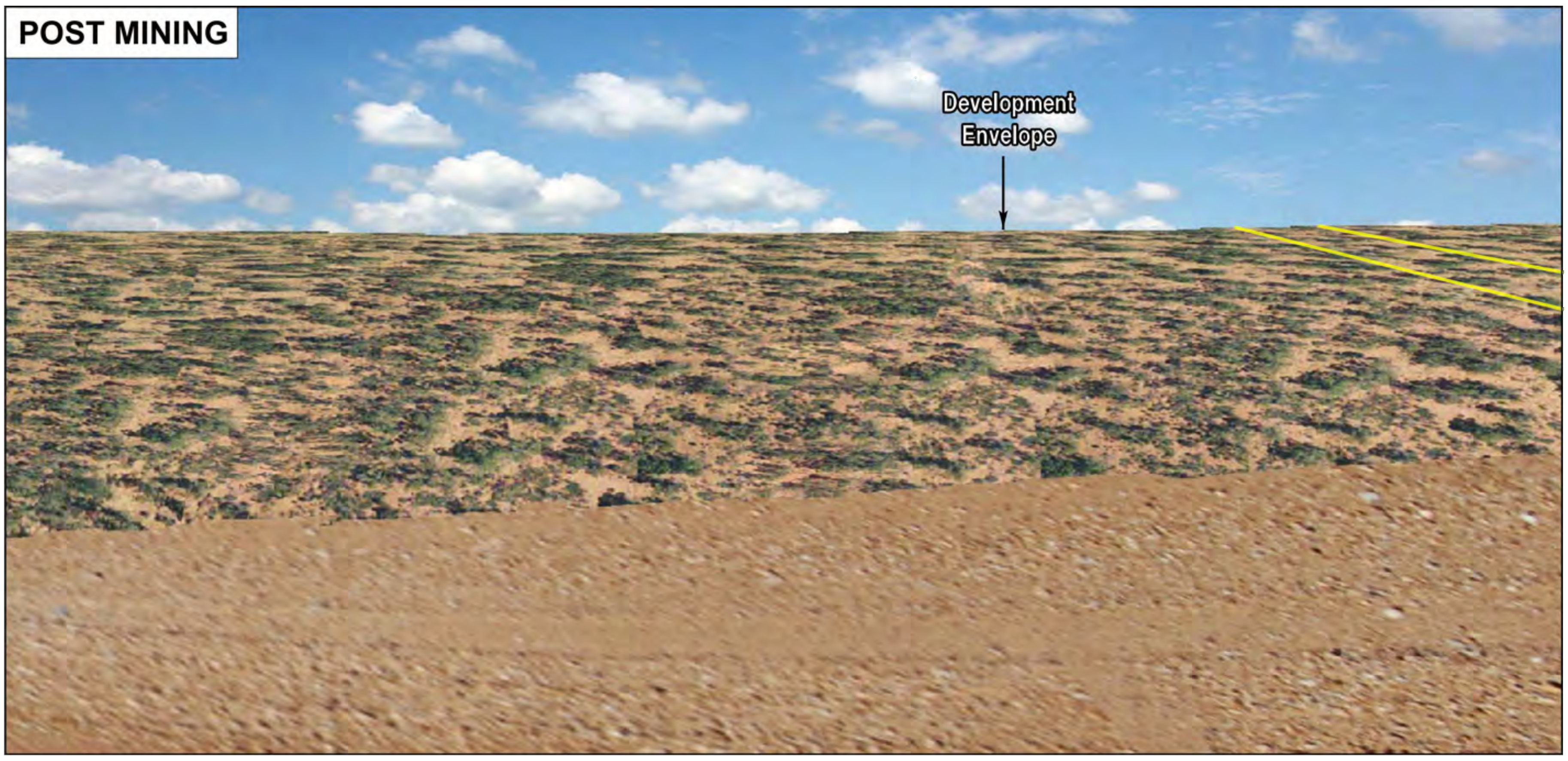

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Scale 1:400,000
MGA94 (Zone 51)

CAD Ref: g2294_PER_09_09.dgn

Date: November 2016 | Rev: B | A4

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Author: C. Dorrington | AE Ref: THO2014-003

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Sandy Ridge Facility

Previous Jaurdi pastoral station
Former Leasehold

Public Environmental Review

Figure:

11-5

11.2 Controlled nuclear action

11.2.1 Nuclear action

Under the EPBC Act, the environment is afforded protection from nuclear actions as a matter of national environmental significance. It is proposed that the Facility would accept the materials listed below that may meet or exceed the threshold concentrations and activities prescribed in Schedule 2 Part 2 of the Australian Radiation Protection and Nuclear Safety Regulations 1999 (Cth):

- Materials containing NORMs generated by industries such as the oil and gas, mining, agricultural, government and industrial sectors. For further clarification, NORMS are radionuclides that are found in the natural environment in a variety of bulk commodities, process wastes and commercial items, sands, clay and soils, rocks, coal, groundwater, oil and gas, metal ores and non-metal ores including fertiliser raw materials such as rock phosphate and apatite (Radiation Health and Safety Advisory Committee, 2005). Processing can modify the NORMS concentrations in the products, by-products and wastes (residues).
- Medical radioisotopes (e.g. X-rays used by doctors, dentists and medical researchers). Radioisotopes are used in the medical profession to provide diagnostic information, treat some medical conditions (e.g. radiotherapy is used in cancer treatment) and to sterilise medical equipment (World Nuclear Association, 2015). Medical isotopes that would be accepted at the Facility would be associated with spent medical equipment, paper, rags, tools, clothing and filters mostly with short-lived radioactivity.
- Commercial and domestic radioactive equipment such as grain moisture metres, disused smoke alarms and gauges.

Accordingly, the Proposed Action may be defined as a ‘nuclear action’ as it involves:

- Establishing a nuclear installation pursuant to Section 22(a) of the EPBC Act. A ‘nuclear installation’ means ‘a nuclear waste storage or disposal facility with an activity that is greater than the activity prescribed by regulations made for the purposes of this section’.
- Establishing a large-scaled disposal facility for radioactive waste pursuant to Section 22(e) of the EPBC Act. ‘Radioactive waste’ means radioactive material for which no further use is foreseen. ‘Large-scale disposal facility’ for radioactive waste means, if regulations are made for the purposes of this definition, a facility prescribed by the regulations. For the definition of large-scale disposal facility in subsection 22(2) of the Act, a facility used for the disposal of radioactive materials at or above the activity level mentioned in regulation 2.02 is prescribed (Environment Protection and Biodiversity Conservation Regulations 2000 – Regulation 2.03).
- An action prescribed by the regulations pursuant to Section 22(g) of the EPBC Act. A nuclear action includes establishing a facility where radioactive materials at or beyond the activity level mentioned in regulation 2.02 are, were, or are proposed to be stored (Environment Protection and Biodiversity Conservation Regulations 2000 – Regulation 2.01).

The Proposal is therefore, a nuclear action.

11.2.2 Assessment of significant impacts on the whole environment

For Proposals that are considered to be nuclear actions, the proponent must describe the nature and extent of likely impacts (both direct and indirect) on the whole environment. This PER document (specifically Chapters 7 to 9) describes the:

- Existing environment in which the Proposal would be located.
- Potential impacts of the Proposal on the whole environment.
- Proposed impact avoidance, mitigation and management measures.

To determine if a proposal's impacts are considered 'significant', the general test for significance applies – that is, whether an impact is: '*important, notable or of consequence, having regard to its context or intensity*'.

In terms of the Proposal's context, the quantity of radioactive waste that would be permanently isolated at Sandy Ridge would be small in the context of the total volume of all wastes proposed to be accepted each year (up to 100,000 tonnes). Approximately 5% of the annual acceptance volume would likely be LLW, but this depends entirely on the volume of waste in the market. Once legacy wastes (which are currently stockpiled around the country) are accepted, the volume of LLW accepted at the Facility would likely decrease.

It is highly unlikely the disposal of LLW would affect:

- People or a community, given the nearest permanent residents are located over 50 km from the proposed Facility. The nearest permanent settlement (Koolyanobbing) is 75 km away. The area surrounding the proposed development envelope is not currently utilised for any specific purpose by the community.
- Water resources, as there are none in the proposed development envelope.
- Landscape, soils, plants or animals, as radioactive material would be isolated sub-surface and revegetation undertaken to rehabilitate the surface of the cells.
- Heritage values or features, as the proposed development envelope has no special environmental features and no special cultural or historical significance.

Therefore, the post management impacts on the environment and people from the handling and storage of LLW are considered to be insignificant. The assessment of significance is summarised in Table 11-1.

Monitoring of the environment and human exposure plays a significant part in ensuring compliance with regulatory standards and minimising any impact on the environment. The proponent's approach to radiation monitoring is set out in Section 5.20 and presented in more detail in Section 10 of Appendix A.14 RMP.

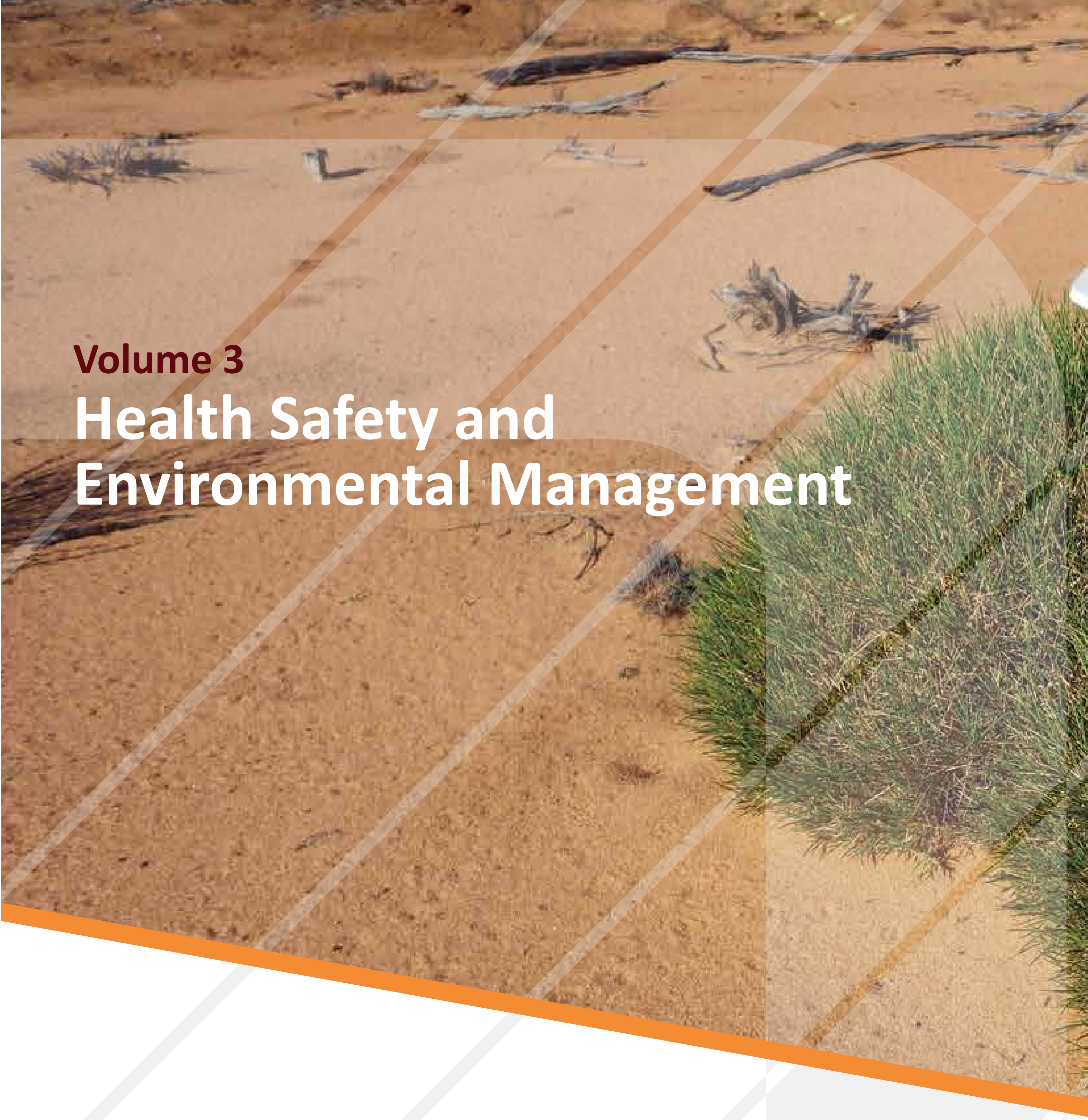
Table 11-1 Assessment of significance of potential residual impacts

Significance of impact	Environmental factor						
	Vegetation and flora			Terrestrial fauna			
Significant residual impacts that would require an offset	Impact on or removal of buffers or other areas necessary to maintain ecological processes and functions for species declared as rare flora under the WC Act or listed as threatened under the EPBC Act.	Impact on or removal of habitat necessary to maintain ecological communities declared as environmentally sensitive areas under the EP Act or listed as threatened ecological communities under the EPBC Act.	Impacts where the existing vegetation is highly cleared (such as complexes with <30% of its pre-clearing extent remaining in a bioregion.	Impact on or removal of buffers necessary to maintain conservation significant wetlands (such as Environmental Protection Policy wetlands, Ramsar wetlands, Conservation Category Wetlands.	Impact on areas reserved under statute or managed for the purpose of conservation e.g. National Parks, Marine Parks, Bush Forever Sites, and Conservation Covenants.	Significant impact on areas recognised as having high biological value (e.g. nationally or internationally recognised biodiversity hotspots) or habitat supporting listed migratory species (such as JAMBA, CAMBA, ROKAMBA).	Impact on or removal of habitat necessary to maintain species declared as specially protected under WC Act or listed as threatened species under the EPBC Act.
Significant residual impacts that may require an offset	Impact likely to result in a species being listed as rare under the WC Act or listed as threatened under the EPBC Act.	Impact likely to result in an ecological community being declared as environmentally sensitive under EP Act or listed as threatened ecological community under EPBC Act.	Impacts in landscapes where the existing vegetation is required to maintain ecosystem services, impact causes a high degree of fragmentation.	Clearing of native vegetation that is watercourse or wetland dependent (such as damplands and floodplains).	Impacts on ecological linkages between conservation areas, contributing to the maintenance or restorability of one or more key ecological processes required to sustain the conservation	Impacts on communities or species that are representative of high biodiversity, have a higher diversity than other examples of an ecological community in a bioregion, or is in 'degraded' condition yet is in better condition	Impact likely to result in a species being listed as specially protected under WC Act or listed as threatened under EPBC Act or impact affects significant

Significance of impact	Environmental factor						
	Vegetation and flora						
				Terrestrial fauna			
					areas or expanding the functional size of an existing conservation area or partially compensating for less than ideal shape.	than other vegetation of the same ecological community in the local area.	habitat for a species.
Assessment of Proposal	No species listed as Threatened under the WC Act or EPBC Act are within the proposed development envelope.	No Environmentally Sensitive Areas listed under the EP Act or listed as TECs under the EPBC Act are within the proposed development envelope.	Clearing for the Proposal would affect Beard vegetation associations 141, 437, 538 and 435. The area to be cleared represents <1% of their current remaining extent. These Beard vegetation associations have greater than 97% of their pre-European extent remaining and are well represented within the Southern Cross IBRA subregion.	No conservation significant wetlands or native vegetation that is associated with a watercourse or wetland dependent (such as damplands and floodplains) is within the proposed development envelope.	Clearing for the water pipeline would disturb 13.32 ha of vegetation within the former Jaurdi Pastoral Lease, which includes 6.44 ha of vegetation within the proposed Conservation and Mining Reserve. This represents <1% of vegetation within the former Jaurdi Pastoral Lease and <1% of vegetation within the Proposed Conservation and Mining Reserve. No conservation	No significant impacts on areas recognised as having high biological value or habitat supporting listed migratory species would occur as a result of implementing the Proposal. The high biodiversity conservation values of the Mount Manning Region are predominantly associated with BIF ranges (EPA, 2007). The proposed development	Clearing for the Proposal would not impact habitat necessary to maintain species declared as specially protected under WC Act or listed as threatened species under the EPBC Act. Malleefowl are likely to occur in the proposed development envelope but only as an occasional visitor. The Malleefowl

Significance of impact	Environmental factor							
	Vegetation and flora							
				Terrestrial fauna				
					significant flora or vegetation would be cleared for the water pipeline.	envelope does not contain BIF or conservation significant flora or vegetation. Although the sandy soils within the proposed development envelope would potentially be suitable breeding habitat for the Rainbow Bee-eater, no recently used burrows were observed within the proposed development envelope. Therefore, Rainbow Bee-eaters may be present transiting across the proposed development envelope only.	favours gravelly soils for mound construction and these lie mostly outside the proposed development envelope (BCE, 2016). Clearing for the proposal would not result in any species being listed as specially protected under WC Act or listed as threatened under EPBC Act. Abundant similar habitat is located immediately adjacent to the development and clearing impacts would not affect significant habitat for any species.

Significance of impact	Environmental factor						
	Vegetation and flora						
				Terrestrial fauna			
Does the Proposal meet the EPA's objective for this environmental factor (Yes/No)	Yes	Yes	Yes	Yes	Yes	Yes	Yes



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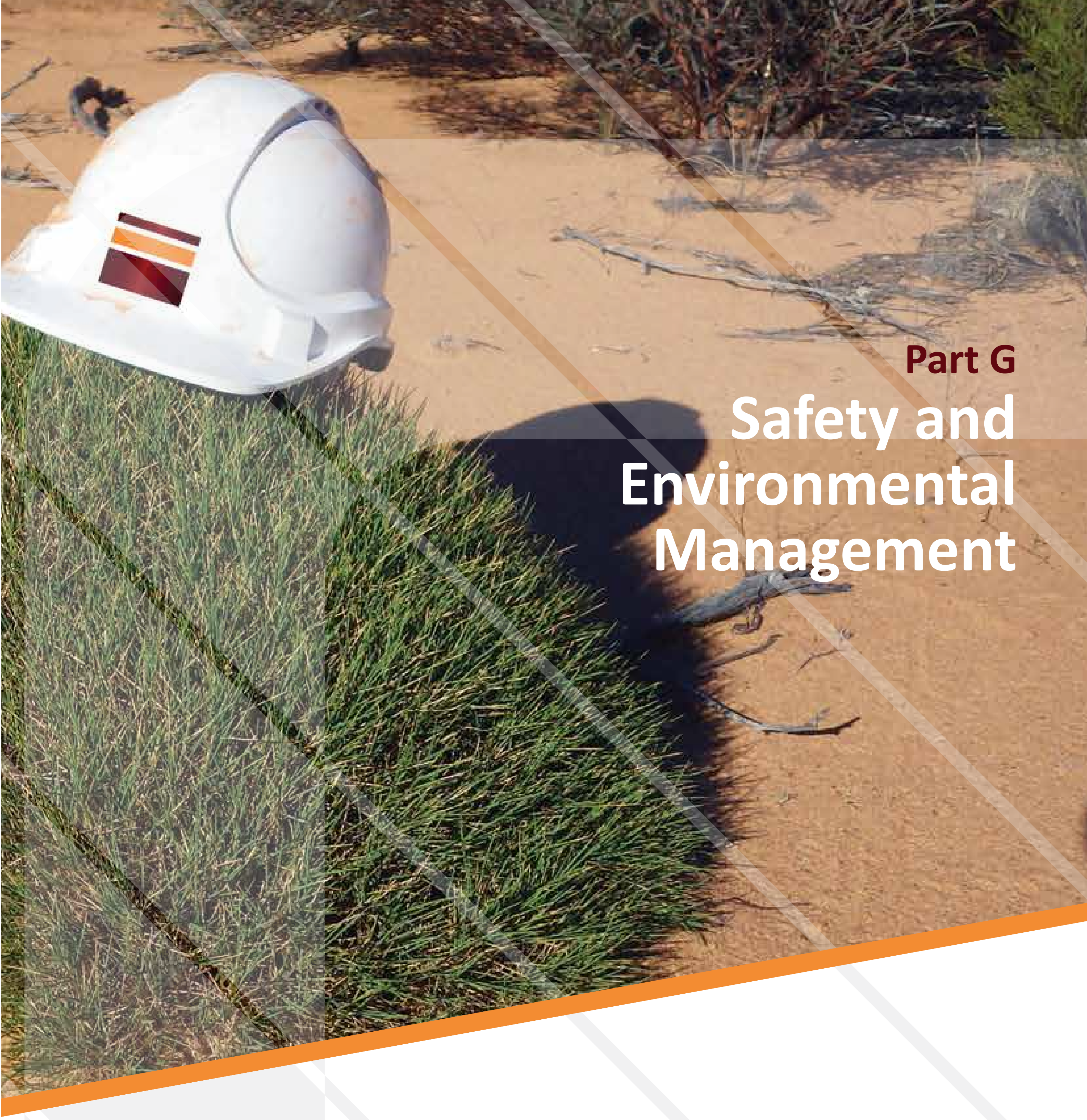


Part G

Safety and Environmental Management

12 MANAGEMENT FRAMEWORK

12.1 Environmental management policy

The proponent is committed to reducing the impact of its operations on the environment. The key principles and actions underpinning its Environmental Management Policy (Appendix A.17) are:

- Incorporate environmental management as part of business activities.
- Monitor and measure environmental performance to ensure continual improvement.
- Periodically review, receive feedback and improve its Environmental Policy and Procedures.

Its environmental objectives are to:

- Operate in a responsible manner that respects the environment at all stages of business.
- Encourage new ways of minimising environmental impacts.
- Strengthen partnerships with stakeholders to achieve objectives and obligations.
- Strive to effectively manage resources, reduce waste and eliminate or minimise adverse environmental effects and risks associated with operations.
- Meet and, where appropriate, exceed applicable environmental laws, statutory obligations and relevant voluntary codes of practice.
- Protect natural, historic and culturally significant sites.

To achieve these objectives, the proponent would act to:

- Ensure that all people who work or visit its operations are aware of and have the necessary skills to fulfil their environmental obligations.
- Openly communicate its environmental performance with its workforce, government and the wider community.
- Ensure high levels of management and staff involvement in achieving stated objectives.

The proponent's Environmental Management Policy is applicable to all its directors and employees. It expresses an ongoing commitment to understand, abide by and regularly review these Key Principles and Actions.

The Environmental Management Policy is the foundation of the EMS and provides the framework for setting and reviewing objectives and targets.

12.2 Environmental management system

The proponent maintains and continuously improves an EMS that complies with the requirements of the International Standard *ISO 14001:2015 Environmental Management Systems*. The EMS would be used by the proponent to manage its environmental responsibilities, manage environmental impacts of the operation, and ensure that effective management of the environment is integral to its operations.

Once all necessary environmental approvals have been obtained for the Proposal, the proponent would update the EMS with management plans and operational procedures relevant to the construction, operation and closure of the Facility.

12.2.1 Planning

This component of the proponent's EMS consists of the following elements: environmental aspects, legal and other requirements, objectives and targets, and environmental management programs.

Environmental aspects and impacts

The proponent has established System Procedure *SP-01 Environmental Planning – Aspects and Impacts* to identify the environmental aspects of its current activities, products and services. The proponent has also detailed methods in SP-01 to determine which of those environmental aspects have a significant impact on the environment.

It is proposed that a comprehensive workshop would be conducted to revise the Environmental Aspects and Impacts procedure including a risk analysis to incorporate activities from the Proposal.

Legal and other requirements

All legal requirements would be updated in regards to the Proposal including requirements under the Ministerial Statement issued.

Objective and targets

The proponent has established System Procedure *SP-03 Objectives and Targets* to identify environmental objectives and quantifiable targets which meet the company's Environmental Management Policy. These environmental objectives and targets would be reassessed in light of the Proposal.

Environmental management program

An Environmental Management Program has been developed for the purpose of turning the objectives and targets into actions. The Environmental Management Program includes performance indicators that would be used to assess environmental performance. This program would be updated in light of the revised *SP-03 Objectives and Targets*.

EMPs being developed for Sandy Ridge are as follows:

- Construction Environmental Management Plan (to incorporate conditions and commitments from the environmental assessment and other approval processes)
- *Surface Water Management Plan* (see Appendix A.10).

- *Radiation Waste Management Plan* (see Appendix A.14).
- *Mine Closure Plan* (see Appendix A.19).
- *Waste Facility Decommissioning and Closure Plan* (see Appendix A.18).
- *Conceptual Emergency Response and Management Plan* (Appendix A.22).
- *Drinking Water Quality Management Plan* (see Appendix A.20).
- Class II Landfill Post Closure Management Plan (prepared prior to closure of the landfill and Proposal life i.e. 25 years).

Implementation and operation

This component of the proponent's EMS is concerned with the implementation of the EMS and the development of necessary capabilities and support mechanisms to achieve the proponent's environmental policy, objectives and targets. This component consists of the following elements:

- Structure and responsibility.
- Training awareness and competence.
- Communication.
- Environmental management system documentation.
- Document control.
- Operational control.
- Emergency preparedness and response.

All components of implementation and operation would be reviewed in light of the Proposal. Particular emphasis and resources would be employed in the area of operational control and emergency preparedness and response.

Operational control

Numerous environmental operational procedures would be developed for the EMS including:

- Vegetation clearing.
- Topsoil management.
- Flora management.
- Heritage management.
- Spill response.
- Oily waste treatment.
- Waste management.

- Chemical management.

Results of the proposed workshop conducted to identify potential adverse impacts would guide the development of new operational procedures. Other operating procedures not necessarily for environmental protection that would guide the operations of the Proposal are listed in Appendix A.16.

Checking and corrective action

This component of the proponent's EMS relates to the monitoring and evaluation of the proponent's environmental performance and consists of the following elements:

- Monitoring and measurement.
- Non-conformance and corrective and preventive action.
- Records.
- Environmental management system audit.
- Management review.

It is anticipated that internal audits would be programmed while integrating the Proposal into the proponent's EMS.

Review and improvement

System Procedure *SP-12 Management Review* was implemented for senior management to undertake reviews to assess the ongoing suitability and effectiveness of the EMS. It is anticipated that the frequency of Management Reviews would need to increase in light of incorporating the Proposal.

12.3 Summary of proposed environmental mitigation

In accordance with the EPBC Regulations, Table 12-1 presents a consolidated list of mitigation measures proposed to be undertaken to prevent, minimise or compensate for the relevant impacts of the action, including mitigation measures proposed to be taken by the WA Governments, local governments or the proponent.

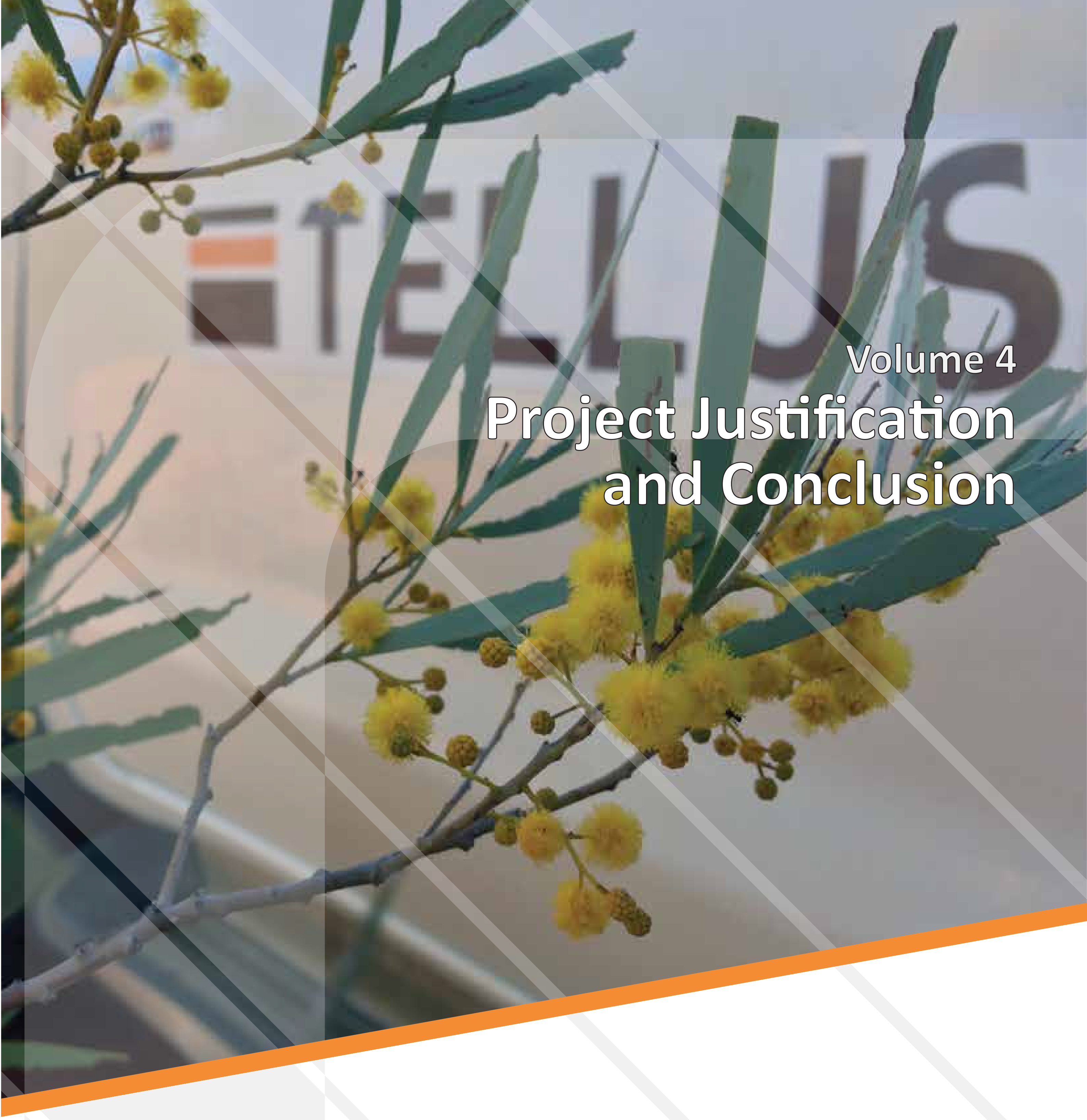
Table 12-1 Summary of environmental mitigation and management measures

Environmental factor/proposed action	Mitigation measures	To be undertaken by:
Flora and vegetation	Develop and implement a CEMP which outlines management and mitigation measures to address potential impacts on flora and vegetation values. A list of measures to be included is provided in Section 10.2.4	The proponent
	Implement fire prevention and management measures to be outlined in a Fire Management Plan.	The proponent
	Rehabilitation of disturbed areas in accordance with the MCP and WFDCP.	The proponent and WA Government
Terrestrial environmental quality	Spill response operational procedures would be implemented. Visual assessments and rapid clean-up of any spill would ensure the extent of the spill is small, and efficient and effective clean-up would minimise dust generation.	The proponent
	The proponent would ensure all operators are trained and familiar with operational procedures and are educated regularly at toolbox meetings. There would be onsite traffic management, including speed limits and two-way communication between all vehicles, to mitigate potential spills.	The proponent
Terrestrial fauna	Pre-clearing surveys would be conducted prior to any ground disturbance to determine if there are any signs of conservation significant fauna activity within the area proposed for clearing.	The proponent
	The CEMP would include fauna management measures to minimise, manage and monitor potential impacts on fauna from the Proposal. A list of measures to be included is provided in Section 10.4.4.	The proponent
	Once detailed design has been completed, include fire prevention measures within a Fire Management Plan.	The proponent
	Rehabilitation of disturbed areas in accordance with the MCP and WFDCP.	The proponent and WA Government
Inland waters environmental quality	Implement an Erosion and Sedimentation Control Plan.	The proponent
	Surface water management measures (e.g. roof canopy, operational bunding, V drains and sumps) would be implemented to protect surface water quality by ensuring it is diverted from operational areas.	The proponent
	Spill response operational procedures would be implemented.	The proponent
	Continue to undertake regular monitoring of the site's existing bore holes.	The proponent
	Continue to undertake weather monitoring and recording.	The proponent

Environmental factor/proposed action	Mitigation measures	To be undertaken by:
	Undertake subsidence monitoring in accordance with the WFDCP.	The proponent
	Hydrogeological modelling is currently being verified by collecting soil moisture data and temperatures at various depths above the silcrete to establish soil moisture profiles during rain events and subsequent dry periods. This would be reported during construction and operation.	The proponent
	Once detailed design has been completed, mapping of potental surface water flooding based on the Rockwater report (2015) would be prepared. This information would form part of the proposed CEMP for the Proposal.	The proponent
	It is recommended that six waterway crossing be constructed as floodways without any raised embankment in oder to minimise scouring along the proposed access road. The road shold be aligned to the east, where practical, to avoid the depression at site R5.	The proponent
	Retaining water near the surface is important so it is allowed to evaporate/evapotranspired. By doing this, it would reduce potential recharge to less than 0.1 mm/year below the proposed clay cap area. Groundwater and climate monitoring should continue through the development of the Proposal. The monitoring of soil moisture probes to establish soil moisture profiles during rain events and dry periods, and at various depths, was installed in April 2016. The proponent would run analysis of both winter and summer soil moisture data in April 2017 to validate soil moisture profiles at the proposed Sandy Ridge site.	The proponent
Human health	The Outline Safety Case is a living document. It would be updated at each step of the development of the Facility, e.g. detailed design, during construction, operation and after closure. The following measures would be addressed as part of a detailed Safety Case: • Implement strict WAC. • Store waste material according to zoning scheme. • Provide extensive training to Sandy Ridge Facility workers. • Enforce appropriate use of personal protective equipment. • Conduct regular toolbox meetings to promote awareness of risks. • Develop clear operational procedures for handling dangerous goods. • Ensure all machinery and equipment used in handling is maintained.	The proponent

Environmental factor/proposed action	Mitigation measures	To be undertaken by:
	• Include spill controls in design of waste isolation pits such as bunds. • Include fire detection and suppression systems in Facility design. • Maintain an emergency response and management plan.	
	Update and implement the Outline Operating Strategy.	The proponent
	Upon completion of detailed design, implement a site specific WAC policy document that is underpinned by the Operating Strategy.	The proponent
	The wastewater treatment system proposed to be installed would meet Shire of Coolgardie requirements.	The proponent
	• Limit the potential for airborne asbestos fibres to be generated through stabilisation and dust control measures. • Limit potential for airborne asbestos to be inhaled by ensuring only people who need be in the vicinity are and they are protected with suitable PPE.	The proponent
	Implement the Drinking Water Quality Management Plan.	The proponent
	Implement the Radioactive Waste Management Plan.	The proponent
	Implement human health monitoring as outlined in the Radiation Waste Management Plan (Appendix A.14).	The proponent
	Best practice noise management would be implemented during operation of the mine to ensure compliance is achieved with the Environmental Protection (Noise) Regulations 1997.	The proponent
Heritage	There are no known records of heritage items (Aboriginal or European) within or in close proximity to the proposed development envelope as confirmed via online database searches (WA Department of Aboriginal Affairs Site Register, State Heritage Register [inHerit], World Heritage Register, National Heritage Register, Commonwealth Heritage Register and the Australian Heritage Database). In addition, a search of the Land, Approvals and Native Title Unit indicated there are no registered native title claims over the proposed development envelope (Government of Western Australia, 2015). Field surveys did not record any heritage items (registered or previously unrecorded) or ethnographic values within the proposed development envelope. The field surveys were conducted in consultation with representatives of the Kapam Native Title Group, Kelamaia Kabu(d)n and Widji Group.	The proponent

Environmental factor/proposed action	Mitigation measures	To be undertaken by:
Amenity	Dust suppression and management measures would be implemented to minimise dust impacts where possible. This would include: • Application of dust suppression methods along internal access roads and hard stand areas using watercarts during dry, dusty periods. • Weather conditions would be monitored prior to mining activities most likely to generate dust (i.e. vegetation removal, topsoil and subsoil stripping, and blasting). • Dust deposition gauges would be installed on the proposed development envelope boundaries nearest to the IWDF and the former Jaurdi Pastoral Lease and monitored quarterly for the initial 12 months. The final locations of dust deposition gauges would be identified in consultation with the DER.	The proponent
	Disposal cells would be rehabilitated on completion of subsidence monitoring with the objective of producing a surface slightly mounded above the existing natural surface that is vegetated.	The proponent
	Following closure of the mine, all mining related infrastructure would be removed and disturbed areas would be rehabilitated.	The proponent
Rehabilitation and decommissioning	Implement the MCP.	The proponent
	The MCP would be reviewed and revised as appropriate by the proponent every three years or such other time as specified in writing by the EPA or DMP. The next review date would follow Ministerial Approval in order to include relevant conditions or requirements regarding closure.	The proponent
	Implement the WFDCP.	The proponent/WA Government
	The WFDCP would be reviewed and revised as appropriate by the proponent every three years or such other time as specified in writing by the EPA or DER. The next review date would follow Ministerial Approval in order to include relevant conditions or requirements regarding closure.	The proponent/WA Government
Nuclear action	Once all necessary environmental approvals have been obtained for the Proposal, the proponent would update the EMS with management plans and operational procedures relevant to the construction, operation and closure of the Proposal.	The proponent



Volume 4

Project Justification and Conclusion

TELLUS

13 JUSTIFICATION AND CONCLUSION

13.1 Justification

The Proposal is considered justified because it:

- Provides diversity in the mining sector.
- Responds to a recognised need and is consistent with WA and national waste management strategies in addition to regional economic strategies and plans.
- Provides a number of community and economic benefits including opportunities for the long-term, storage, treatment and recovery of valuable materials or the permanent isolation of hazardous, intractable and LLW in addition to long-term full-time employment.
- Would not result in significant effects on the environment.
- Is consistent with the principles of sustainability and environmental protection.

Proceeding with the Proposal would result in significant social and economic benefits, including:

- Providing a unique dual revenue business that commercialises an industrial bulk commodity (kaolin) and provides safe management solutions for difficult to manage hazardous waste resources.
- Future potential recovery of valuable materials.
- Long-term jobs and major investment and business opportunities in remote regional Australia.
- Diversification of the economy by an environmental infrastructure business with strong social, environmental and economic values.
- Royalties, taxes and levies over the 25 year term could support other parts of the economy.
- Employment and business opportunities that can support local and regional communities.
- Long Proposal life of 26 years. The site can be expanded for generations (1 year build, 25 year operation).
- Creation of approximately 90 jobs during the build phase, and approximately 23 direct and 46 indirect (2x multiplier) during the operation phase.
- Benefits would apply to local Indigenous communities where opportunities for training, employment and business opportunities during construction and operations exist.
- When operating, the Facility would also provide a reliable long-term utility service to other industries that produce waste materials within Australia.
- The Facility could attract new kaolin and waste recycling and recovery industries to WA, and support industrial development in WA, bringing attendant economic benefits.

13.1.1 Environmental effects

Detailed scientific desktop and field investigations were undertaken to assess key environmental factors and to discuss their potential environmental impacts, positive or negative, during both construction and operation of the Proposal. These included specialist studies of biodiversity, soils, cultural heritage, surface, groundwater and radiology.

Potential environmental impacts of the Proposal are documented in this PER. Mitigation and management measures have been documented to avoid and/or reduce potential impacts identified during various risk assessments. Based on the environmental impact and risk assessment, the Proposal would result in the following (direct) environmental impacts:

- **Flora and vegetation**: up to approximately 276.05 ha of native vegetation would be removed during the construction of the Facility. Direct clearing of each vegetation association present within the proposed development envelope represents clearing less than 1% of their current remaining extent in the region. There would be no impacts on Threatened or Priority Ecological Communities (listed under the WC Act) or Threatened or Endangered Ecological Communities (listed under the EPBC Act). In addition, there would be no impacts on flora species listed as having conservation significance under the WC Act or the EPBC Act. These species would be avoided during construction and operation of the Proposal.
- **Terrestrial fauna**: the removal of up to approximately 276.05 ha of native vegetation would result in the loss of foraging, breeding, roosting, sheltering and/or dispersal habitat for some fauna species. Most fauna species are not confined to a specific habitat type, and given the presence of large areas of suitable adjoining habitat, the proposed clearing would not have a significant impact on fauna habitats. Clearing of vegetation would not likely have a significant impact on fauna species listed as having conservation significance under the WC Act or the EPBC Act. All fauna species would readily move to adjacent undisturbed vegetation once vegetation clearing commences.

Mitigation measures that would be implemented during both construction and operation have been proposed to avoid (eliminate) or ensure potential impacts are short-term and easily managed. The environmental performance of the Proposal would be managed through the implementation of construction and operational environmental management plans and monitoring programs. This would also help to ensure compliance with relevant legislation and any conditions of approval.

Based on the above, construction and operation of the Facility would not result in a significant environmental impact, provided the mitigation and management measures outlined in this document are implemented. The Proposal would meet the environmental objectives described in the EPA's Environmental Assessment Guideline No. 8 (2015a).

13.1.2 Consideration of the principles of sustainability and environmental protection

The principles of sustainability and environmental protection include:

- **Precautionary principle**. Where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.
- **Inter-generational equity**. The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.
- **Conservation of biological diversity and ecological integrity.** The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision making.
- **Improved valuation, pricing and incentive mechanisms**. This includes recognition of the principles that the costs of environmental externalities should be internalised and that the polluter should bear the costs associated with environmental pollution.
- **Waste minimisation.** All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.
- **Best practice**. When designing proposals, and implementing environmental mitigation and management actions, the contemporary best practice measures available at the time of implementation should be applied.
- **Continuous improvement**. The implementation of environmental practices should aim for continuous improvement in environmental performance.

An assessment of the Proposal against these principles is provided below.

Precautionary principle

A number of environmental investigations have been undertaken to ensure that the potential impacts of the Proposal are understood with a high degree of certainty. Where a higher degree of risk was identified, this included specialist studies. The assessment of potential impacts of the Proposal is considered to be consistent with the precautionary principle. The assessments undertaken are consistent with accepted scientific methodologies, and have taken into account relevant statutory and government agency requirements.

The Proposal has evolved to avoid environmental effects where possible and to reflect the findings of the studies undertaken. For example, the location of cells could be located to avoid plant species that have potential conservation significance. Safeguards have also been proposed to minimise the potential environmental impacts. These safeguards would be implemented during construction and operation of the Facility. A CEMP and OEMP would be prepared prior to construction or operation of the Facility.

Inter-generational equity

Construction and operation of the Facility has the potential to lead to some environmental and social disturbance. These disturbances include potential temporary elevated levels of traffic, noise and dust generation during construction. There would also be an increased potential for hazards and risks (spills, etc.) during operation. However, strict implementation of the CEMP and OEMP would ensure there would be no significant impact that would diminish the health, diversity or productivity of the environment for present or future generations.

Conservation of biological diversity and ecological integrity

Surveys of flora and vegetation and a fauna assessment has been undertaken to identify potential adverse impacts on biodiversity. These studies demonstrate that the Proposal would not have significant impact on any local populations of native biota including threatened and endangered species, populations or ecological communities.

Improved valuation, pricing and incentive mechanisms

The environmental impact assessment has identified the environmental and other consequences of the Proposal and identified mitigation measures where appropriate to manage potential adverse effects. If approved, the construction and operation of the Proposal would be in accordance with relevant legislation, the conditions of approval and the CEMP and OEMP. These requirements would result in an economic cost to the proponent. The implementation of mitigation measures would increase both the capital and operating costs of the Proposal. This indicates that environmental resources have been given appropriate valuation in the development of the Proposal.

Waste minimisation

It is estimated that about 3.2 million tonnes of legacy wastes are temporarily stored in over 200 locations across Australia, awaiting an appropriate long-term storage option. The Proposal would minimise waste that is currently stored in temporary and often inappropriate storage locations, by providing a suitable near surface geological repository for permanent isolation of hazardous and intractable wastes.

Best practice

Best practice has been implemented in the design of the Proposal by reviewing practices at international LLW isolation facilities and adhering to international and national codes for isolation of LLW. It is considered best practice to prepare a Safety Case for a LLW near surface geological repository. At this stage of the Proposal, the proponent has prepared an outline Safety Case which is provided in Appendix A.15.

Recommendations for environmental mitigation and management measures specified by technical experts have been included in this PER to eliminate or reduce the potential environmental impacts associated with the Proposal.

Continuous improvement

Continuous improvement and corrective actions are of paramount importance, and are a fundamental part of the EMS. An environmental monitoring program enables auditing of mitigation measures to ensure they achieve their objectives and to facilitate modification, where necessary. An environmental monitoring program would be established for both the construction and operational phase of the Proposal. Monitoring requirements would be listed within the CEMP and OEMP.

13.2 Conclusion

13.2.1 Conclusion

Sandy Ridge is located 240 km north-west by road from Kalgoorlie and 75 km north-east of Koolyanobbing in WA. Sandy Ridge is a very remote site. It is located within a semi-arid environment where annual average evaporation rates are approximately eight times higher than annual average rainfall. The site has been geologically stable and arid for millions of years and is highly likely to remain so.

The proponent proposes to develop a dual revenue business comprising a kaolin open cut mine. The mine would produce up to 290,000 tpa of ore, and up to 40,000 tpa of mostly ceramics for the Asian export market from an onsite kaolin processing plant. By using the voids resulting from mining for the secure storage, recovery of valuable materials may one day be possible. The Proposal would see the permanent isolation of up to 100,000 tpa of hazardous and intractable waste using a best practice safety case over a 25 year operating life.

This Public Environmental Review has been prepared to support the approval of the Proposal under Part IV of the WA *Environmental Protection Act 1986* and, under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth). The Public Environmental Review has been prepared to address the requirements set out in the final ESD for the Proposal issued by the WA OEPA on 27 May, 2016. The Public Environmental Review has also been prepared to address the requirements set out in Schedule 4 of the Environment Protection Biodiversity Conservation Regulations.

Mining kaolin clay would diversify the WA mining sector and help strengthen the circular economy. The Sandy Ridge Proposal would provide long-term training and job opportunities at a local and regional level.

There is a need and obligation to provide for the safe and secure storage of hazardous, intractable and low level radioactive wastes that continue to be generated across a wide spectrum of business and research organisations within Australia. Currently, such wastes are stored in hundreds of locations across Australia, often in unsecured and inappropriate locations. The current management of such waste types can lead to significant and potentially long-term adverse impacts on human populations and our environment.

The kaolin ore would be temporarily stored at the Sandy Ridge site before being transported by road to Freemantle Port. From there, it would be loaded onto ships and exported to Asia for production in dinnerware products.

Before arriving at Sandy Ridge, waste products would be temporarily stored at strategic warehouse locations that are appropriately rated and licensed. The bulk of waste products would be transported by rail to Kalgoorlie.

The Sandy Ridge Proposal has been developed and designed in accordance with similar facilities currently operating best practice techniques in France and Spain. The Proposal offers the waste industry and government regulators an opportunity to provide an economically and practically accessible end point solution for hazardous and intractable waste storage and isolation in Australia.

Environmental investigations were undertaken to assess the potential impacts from the construction and operation of the Proposal in accordance with relevant environmental legislation and relevant guidelines and procedures established by regulatory agencies. Based on the findings of the environmental investigations, the Proposal would result in some short-term adverse effects on the environment. These effects would be easily managed and mitigated by implementing the various environmental mitigation measures outlined in this PER. They would also be managed by adhering to relevant legislation, regulations, policies and guidelines.

If approved, the environmental performance of the Proposal would be managed through the implementation of a construction environmental management plan and an operational environmental management plan. Both plans would be underpinned by site specific and detailed environmental management plans. The preparation and implementation of such plans would ensure compliance with relevant legislation, regulation and any conditions of approval.

It is considered that the Proposal is justified on the basis that it meets the standards required for a near surface geological repository, and is environmentally acceptable because it has been assessed to meet necessary Commonwealth and WA regulations and guidelines. In addition, the Proposal has been assessed within this PER as being in accordance with the principles of sustainability and environmental protection.

Based on this PER, it is considered that the long-term operational benefits of the Proposal would outweigh the short term, minor adverse effects identified in the risk assessment.

13.2.2 Recommendations

It is recommended that the Proposal be approved for the following reasons:

- The Public Environmental Review has addressed the requirements of work set out in the Environmental Scoping Document. It has also addressed all necessary environmental guidelines as required by the Office of the Environmental Protection Authority and the Commonwealth Department of the Environment.
- The assessment of key environmental factors has involved detailed quantitative scientific assessment and consultation with key government and non-government stakeholders. The assessment has concluded the Proposal can be constructed and operated without resulting in significant risks on either the environment or human populations.

- Where the risk assessment has identified potential issues, the environmental assessment has proven, by way of modelling and consultation, those issues can be easily managed through tailored environmental management measures that meet relevant government and best practice guidelines.
- The site is located on vacant Crown reserve which is not constrained by any matters of national environmental significance under the *Environment Protection Biodiversity Act 1999*. The site has been extensively surveyed for potential rare, threatened or endangered plants and/or animals. There would be no impacts on Threatened or Priority Ecological Communities (listed under the WC Act). Field survey results confirm the site is not constrained by sensitive plants or animals and it lacks the necessary habitat for such species to occur.
- The potential environmental, social and economic benefits of the Proposal outweigh any potential negative issues. If approved, the Proposal would address what is a serious legacy intractable waste issue in Australia. It would result in long-term, inter-generational jobs at both the regional and local employment level. The Proposal would encourage regional investment, training, business opportunities, growth in infrastructure, royalties and taxes for Western Australia.
- In a period when the Australian mining sector is experiencing a significant downturn, the Proposal promotes diversification by introducing kaolin mining. The kaolin resource can be mined for 25 plus years thus ensuring long-term stability in the WA mining sector.
- If approved, the Proposal would positively contribute to several initiatives put forward by government authorities such as the Australian Government *National Waste Policy* and the WA Government *Western Australian Waste Strategy.* It would also be consistent with the aims and objectives of numerous strategic plans prepared for the Goldfields-Esperance Region.
- By storing like with like wastes, the Proposal can provide for future waste recovery and re-use projects. This in turn creates opportunities for current and future research opportunities.
- The 'do nothing' option would not realise the potential benefits that have been identified in this PER.

14 PER TECHNICAL TEAM

The team of technical specialists that were involved in providing technical studies and advice for this PER are listed in Table 14-1.

Table 14-1 Technical contributors to the PER

Team member	Role
Aurora Environmental	Lead consultant
PGV Environmental	Flora and vegetation surveys
Landloch Pty Ltd	Soil assessment, clay cap characterisation and landform evolution modelling
Terrestrial Ecosystems	Terrestrial fauna survey
Bamford Consulting Ecologists	Targeted Malleefowl survey
Rockwater Pty Ltd	Hydrogeological and hydrological studies
CyMod Systems Pty Ltd	Infiltration and seepage modelling
Hygiea Consulting	Radiation assessment and management
John Cecci Heritage Management Consultancy	Heritage survey
Terra Search	Geology and Mineral Resource assessments
Continental Resource Management	Geology and Mineral Resource assessments
Environdata	Weather station provider
Mining Plus	Engineering and design
Hampton Mining & Civil	Engineering and design
Douglas Partners	Geotechnical assessment
Big Picture Communications	PER editor

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References

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15 REFERENCES

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