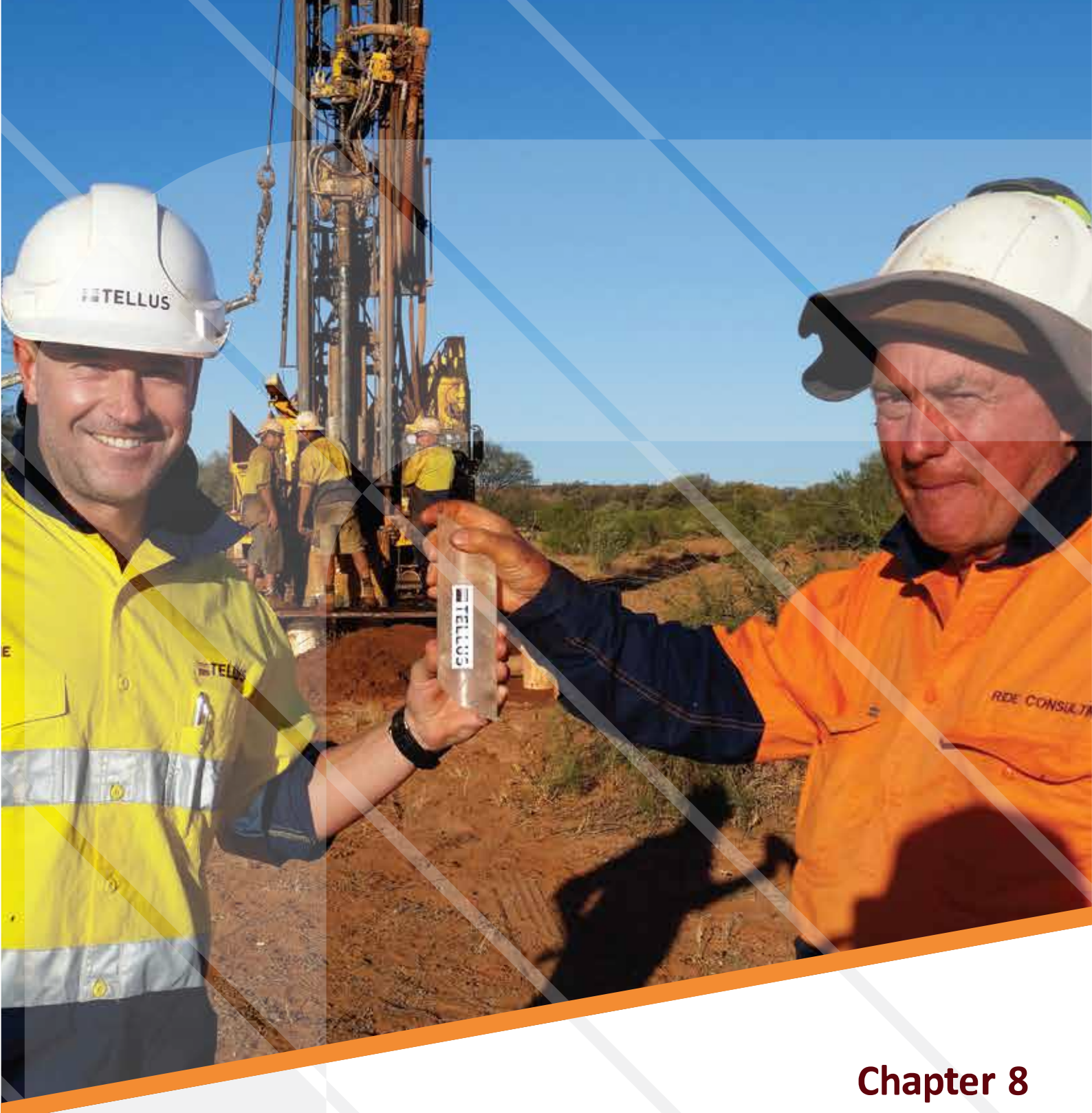


Chapter 8
Groundwater

TELLUS

This page has been left intentionally blank

8 GROUNDWATER

8.1 Introduction

This chapter provides a review of local and regional hydrogeology and groundwater resources that may be potentially affected by the construction, operation and closure of the Proposal. The review draws on the following (see Appendix P) that were undertaken to support the groundwater impact assessment for the Proposal:

- Geo 9 (2015).
- Atkins (2015).
- Quintessa (2016).
- EMM (2017).

Local and regional groundwater conditions are described. The potential impacts on local and regional groundwater resources, users and potential dependant ecosystems are assessed. Mitigation, management and monitoring measures are subsequently identified with the objective of reducing potential impacts during construction, operation and following closure of the Proposal. A draft Water Management Plan is also provided in Appendix Q.

The groundwater assessment has been prepared in accordance with the Terms of Reference (refer to Appendix A).

8.2 Methodology

This section describes the methodology used for the groundwater assessment. The methodology included a review of available literature, analysis of data collected from a groundwater monitoring network established within and around the Proposal area, conceptual groundwater modelling and groundwater impact assessment, mitigation and management strategy.

8.2.1 Literature review

A review of published geotechnical and hydrogeological reports was undertaken to collate information on the regional physical environment, including climate, topography, land use, surface water, geology, hydrogeology and water dependent ecosystems and other sensitive receptors.

The review has a focus on groundwater and surface water environments across the south-east of the Northern Territory and the north-west of South Australia. A summary of the critical information sources is included in Appendix N.

8.2.2 Groundwater monitoring and field investigations

Groundwater monitoring is an essential component in characterising the Proposal area baseline (pre-mining) hydrogeological and hydrological environments. Baseline water level and quality data

collected from the various aquifers and watercourses is used to understand flow paths, recharge and discharge characteristics, and groundwater–surface water connectivity. The collection and analysis of field data was used to establish the conceptual (hydrogeological) model.

A dedicated groundwater monitoring network for the Proposal was designed and installed in May 2015 to investigate the local hydrogeological conditions across the proposed development footprint and vicinity. Following installation of the network, 15 months of groundwater monitoring data was collected at monthly intervals including baseline groundwater level and groundwater quality data.

The groundwater monitoring network (Figure 8-1) was designed to provide reasonable spatial coverage to investigate the main hydrogeological systems.

The groundwater monitoring network:

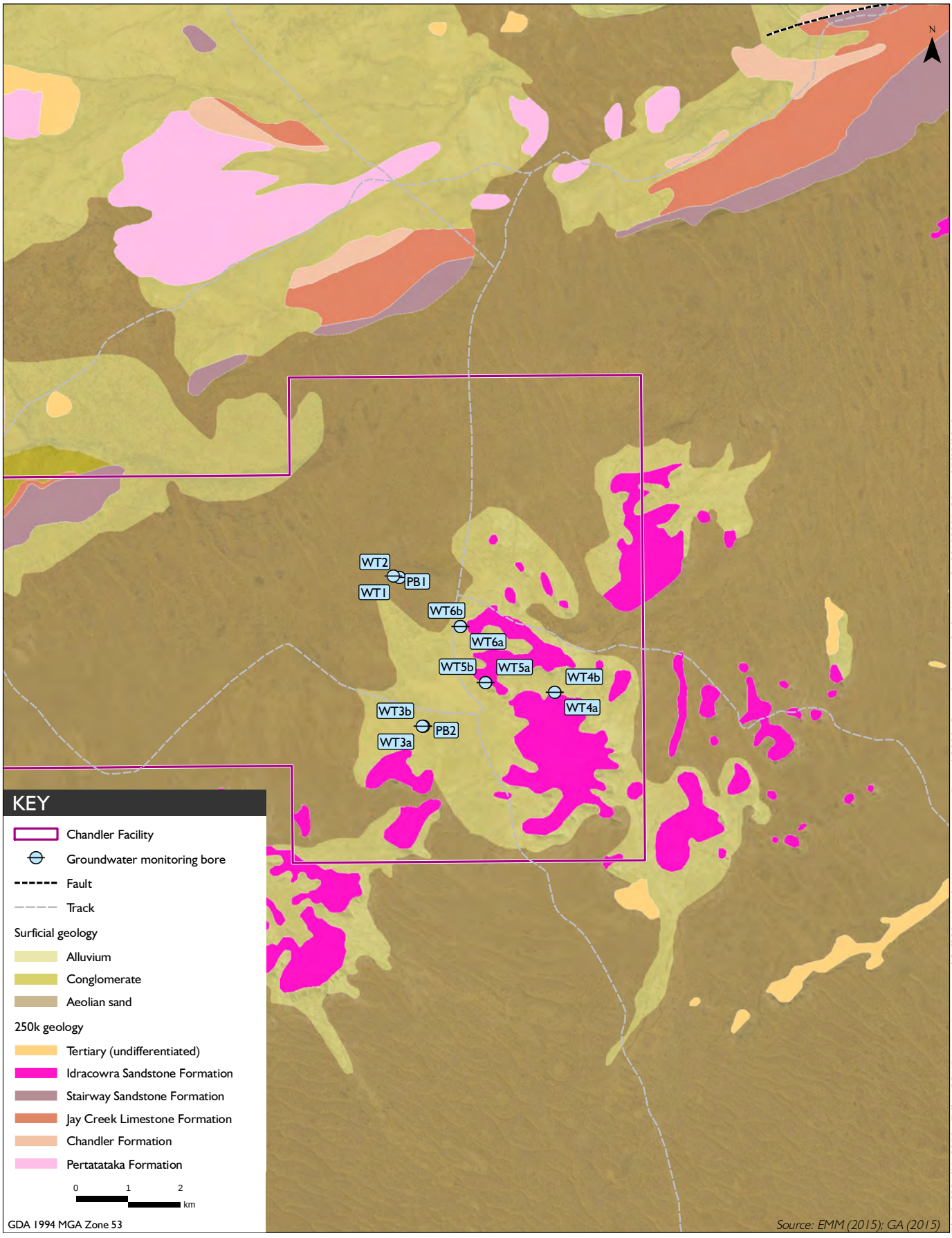
- Identifies and characterises water bearing units (aquifers) and aquitards in the Chandler Facility area, with focus on characterising groundwater flow and quality within the main groundwater bearing units, the Horseshoe Bend Shale Formation and the Langra Formation, which both overlie the Chandler Formation (salt deposit) by hundreds of metres.
- Provides spatial representation of pressure heads across the Chandler Facility area to investigate potential vertical hydraulic gradients and potential connectivity between water bearing units.

Groundwater quality data collected from the monitoring network was assessed using the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC 2000). These guidelines describe requirements over a variety of marine and freshwater environments, aquatic ecosystems, primary industries, recreational water, drinking water and monitoring and assessment.

With the aim of further characterising the extent and hydraulic properties of the local groundwater environment, the assessment also included a review of data collected during a groundwater pumping test at the Proposal site, and a review of downhole and surface geophysical survey data.

Pumping tests are conducted by pumping water from a test bore at a constant rate and duration that stresses the aquifer and initiates a groundwater level response (drawdown) in monitoring bores. Tests are designed as a direct and reliable way to obtain estimates of aquifer properties including storativity, transmissivity and horizontal hydraulic conductivity. Pumping tests can also provide information on the extent and sustainability of the aquifer and the degree of connection with nearby surface water bodies if present.

Specialist groundwater assessments (Appendix P) provide details of the design, construction and installation of the groundwater monitoring network, and further details of the field investigations.



T:\Jobs\2016\J16072 - Tellus CSMP Water Assessment\GIS\02_Maps_WaterAssessmentReport\G006_GroundwaterMonitoringNetwork_20160907_06.mxd 7/09/2016

TELLUS

Groundwater monitoring network
Chandler Facility
Figure 8.1

8.2.3 Groundwater modelling and water balance

The Terms of Reference included a requirement for: “A conceptual site model describing potential sources, pathways, receptors, and fate of any potentially contaminated waters. The model should be of sufficient detail for the general reader to understand the source(s) of potential contaminants, the mechanism(s) of their release, the pathway(s) for transport, and the potential for human and ecological exposure to these potential contaminants.”

The *Australian Groundwater Modelling Guidelines* (NWC 2012) define a conceptual model in terms of a descriptive representation of a groundwater system that incorporates an interpretation of the geological and hydrological conditions consolidating the current understanding of the key processes of the groundwater system. The conceptual model assists in the understanding of possible future changes to the system and can be modified and refined as additional field data is collected.

Section 3 of the *Australian Groundwater Modelling Guidelines* provides guidance on conceptualisation, and specifies that development of the conceptual model should consider:

- Hydrogeological stratigraphy (including the occurrence and extent of aquifers)
- Aquifer properties.
- Conceptual boundaries.
- Stresses on the groundwater system.
- Groundwater flow processes and surface water groundwater interactions.

These criteria have been addressed throughout the Groundwater Assessment, and in the development of a conceptual (hydrogeological) model in accordance with the guideline and for the purpose outlined in the terms of reference.

An initial conceptual water balance was also completed for the Proposal based on the conceptual mine plan and provides an estimate of water inflows, outflows and storage within the system.

The conceptual model and water balance assist in the understanding of possible future changes to the system and are based on both qualitative and quantitative information derived from the literature review and groundwater monitoring and field investigations.

8.2.4 Groundwater impact assessment

The Groundwater Assessment includes an impact assessment which uses the conceptual model to assist in the assessment of potential impacts of the Proposal, specifically:

- Impacts from predicted changes in groundwater level and quality of groundwater, surface water, groundwater dependant ecosystems and landholder bores.
- Sources of potential contaminants, mechanisms of their release, pathways for transport, fate of any potentially contaminated waters, and the potential for human and ecological exposure to potential contaminants.

Hydro-stratigraphic and geo-mechanical impacts of the Proposal are also assessed in this review.

8.2.5 Risk management, mitigation and monitoring

In accordance with the Terms of Reference, a risk assessment matrix was used to quantify the level of risk (risk rating) based on the following: the likelihood of a potential impact occurring; and the consequence of a potential impact. Based on the risk ratings, the assessment includes the identification of management, mitigation and monitoring measures during the development, operation and closure of the Proposal.

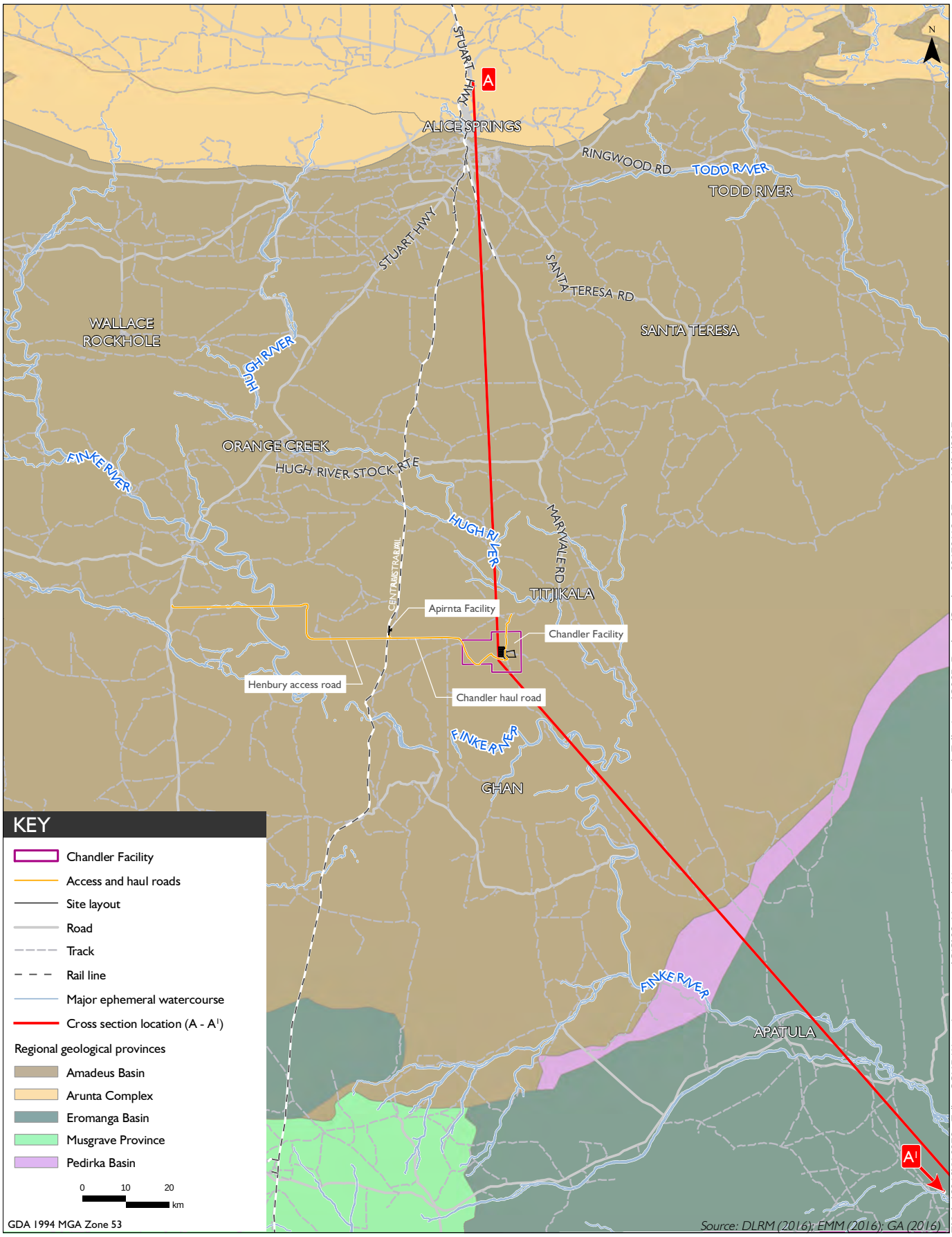
8.3 Existing environment

This section describes the regional geological and hydrogeological setting and sensitive receptors in the vicinity of the Proposal.

8.3.1 Regional geological setting

The regional geological setting in the vicinity of the Proposal in south-east NT and northern South Australia is dominated by three geological basins – the Amadeus Basin, Pedirka Basin, and the Eromanga Basin (Figure 8-2 and Figure 8-3). The Proposal is located within the Chandler Syncline sub-basin that forms part of the south-eastern extent of the Amadeus Basin, the most northerly of these three major basins.

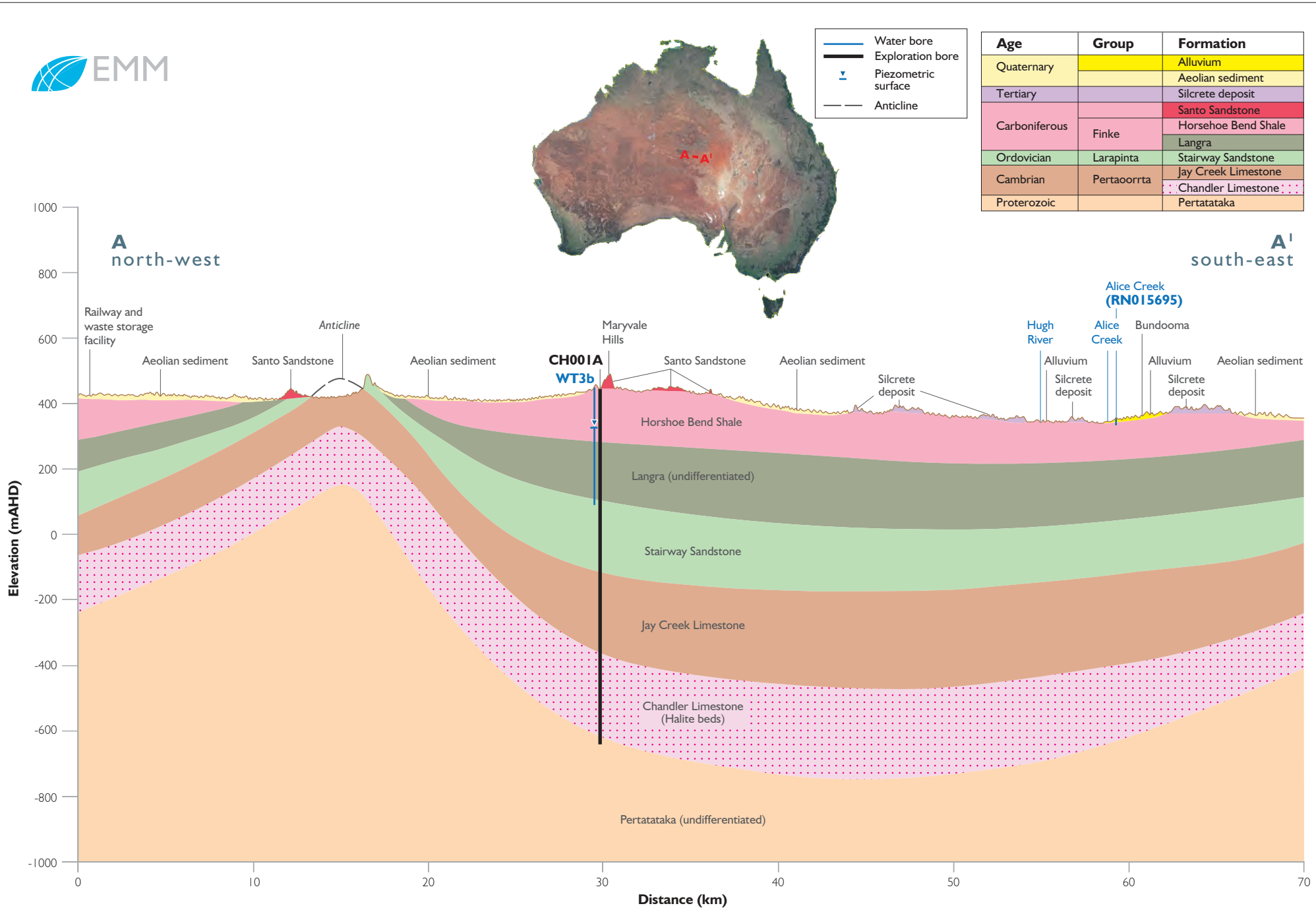
The extent, depositional context and structure of the Amadeus Basin are described below. The Pedirka and Eromanga Basins are described in detail in the Groundwater Assessment (Appendix P).



Regional geological provinces

TELLUS

Figure 8-2


EMM
Water bore
Exploration bore
Piezometric surface
Anticline
A - A'
Age
Group
Formation
Quaternary
Alluvium
Aeolian sediment
Tertiary
Silcrete deposit
Carboniferous
Santo Sandstone
Finke
Horsehoe Bend Shale
Langra
Ordovician
Larapinta
Stairway Sandstone
Cambrian
Pertaoorrta
Jay Creek Limestone
Chandler Limestone
Proterozoic
Pertatataka
A
north-west
A'
south-east
Railway and waste storage facility
Aeolian sediment
Santo Sandstone
Anticline
Aeolian sediment
CH001A
WT3b
Maryvale Hills
Santo Sandstone
Aeolian sediment
Silcrete deposit
Hugh River
Alluvium
Silcrete deposit
Alice Creek
Alice Creek (RN015695)
Bundooma
Alluvium
Silcrete deposit
Aeolian sediment
Horshoe Bend Shale
Langra (undifferentiated)
Stairway Sandstone
Jay Creek Limestone
Chandler Limestone (Halite beds)
Pertatataka (undifferentiated)
Elevation (mAHD)
1000
800
600
400
200
0
-200
-400
-600
-800
-1000
0
10
20
30
40
50
60
70
Distance (km)

Amadeus Basin

The Proposal area lies within the Chandler Syncline sub-basin of the south-eastern extent of the Amadeus Basin. The Amadeus Basin is an extensive asymmetrical east-west trending, elongate sedimentary basin with an area of approximately 155,000 square kilometres (Lloyd and Jacobson 1987). The south-eastern extent of the Amadeus Basin abuts the Pedirka Basin about 80 kilometres south-east of the Proposal area (and close to the north-western extent of the Eromanga Basin – Figure 8-2). The land surface is structurally controlled to the north, east and west by a series of extensive Palaeozoic orogenies including Precambrian intrusive and metamorphic rocks (Lloyd and Jacobson 1987). Alluvial sediments dominate low lying areas.

The Basin comprises a series of synclinal sub-basins defined by numerous folds and thrust belts. The three predominant sub-basins are: the Northern Amadeus Sub-basin; the Orange Creek Syncline; and the Chandler Syncline. The Proposal lies within the southern-most Chandler Syncline sub-basin.

The predominant marine and terrestrial sedimentary sequences that form the Amadeus Basin were deposited about 500 million years ago (Alley and Gravestock 1995). The deposits include: dolostone, limestone, shale, sandstone, siltstone, quartzite, evaporite, diamicite and conglomerate (NT Department of Mines and Energy 2016). The sedimentary sequences reach a maximum thickness of around 8 kilometres, however the Chandler Syncline sub-basin depth extends to around 2 kilometres.

Several significant geological events have influenced the structure and geological composition within the Amadeus Basin. Sedimentation of dolomitic siltstones and sandstones in the Late Proterozoic was terminated by a period of mountain building, salt deposition, folding and thrusting, particularly in the north-western area of the basin (Wells et al. 1970). During the Cambrian period, continental sedimentation persisted in the north-west, while shallow marine shales, carbonates and evaporites were deposited in the north-east (Lloyd and Jacobson 1987). Ocean regression terminated marine deposition in the Late Ordovician period (Coffey 2012). The Alice Springs Orogeny, in the Carboniferous period, was a major mountain building period resulting in extensive folding and faulting in the Amadeus Basin (Lloyd and Jacobson 1987).

The stratigraphic summary and associated mountain building periods (orogenies) of the south-eastern extent of the Amadeus Basin observed across the Proposal area are shown in Table 8-1. The key geological units encountered by the Proposal are highlighted in different shades of orange.

Table 8-1 Stratigraphic summary of the south-eastern extent of the Amadeus Basin

Age	Group	Formation	Hydrogeology
Quaternary		Alluvium	Aquifer (perched)
		Aeolian sediment	Aquifer (perched)
Tertiary		Silcrete deposit	Aquatard (local)
Carboniferous		Idracowra Sandstone	Aquifer
Devonian			Aquifer
	Finke	Horseshoe Bend Shale	Aquifer
		Langra	Aquifer
Ordovician	Larapinta	Stairway Sandstone	Aquifer
Cambrian	Pertaoorrta	Jay Creek Limestone	Potential aquifer
		Giles Creek Dolostone	Potential aquifer
		Chandler	Not applicable
Proterozoic		Pertataka	Unknown

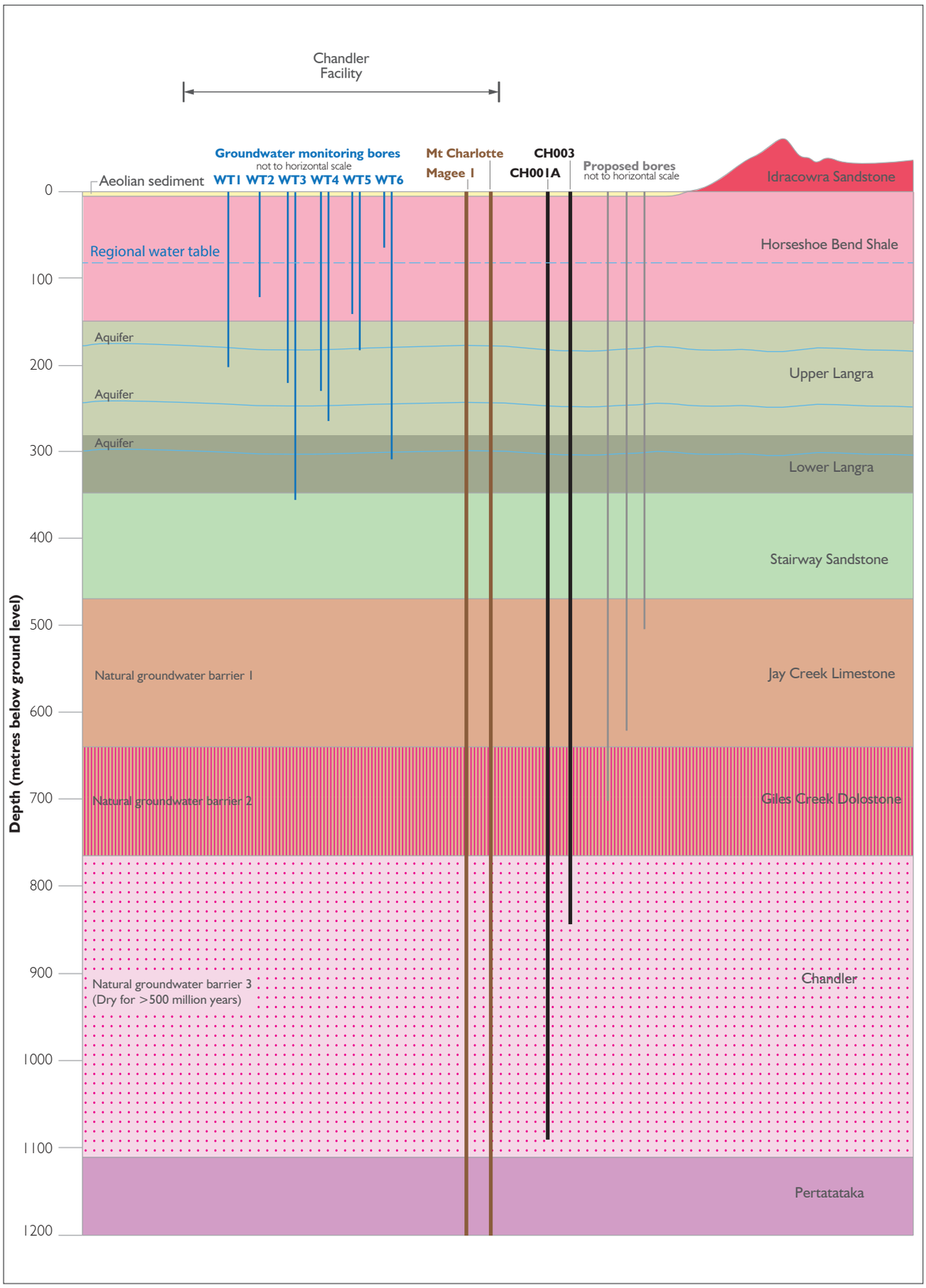
8.3.2 Local geological setting

The Proposal targets the Chandler Formation, a unit of the Pertaoorrta Group of Cambrian age (485-541 million years old) within the Chandler Syncline of the southern Amadeus Basin. Despite the complex history of the Amadeus Basin, the strata in the area of the Proposal are relatively flat lying and continuous.

The geological structure in the area of the Proposal has been investigated by some 2D seismic coverage in the area (reprocessed as part of the Tellus investigations), and sampled by four deep boreholes and nine shallower boreholes. The four deep boreholes reach the Chandler Formation; two were drilled by Tellus (CH001A and CH003), and two are pre-existing oil exploration wells (Mt Charlotte No. 1 and Magee) (see Figure 8-4).

CH001A lies at the northern margin of the underground footprint of the facility, while the other boreholes are outside the Chandler Facility footprint. Both CH001A and CH003 were drilled to the base of the salt for site investigation purposes and were subsequently fully sealed with cement grout. CH001A was fully cored. Additionally, 9 shallower boreholes, with depths of up to 360 metres, were drilled within the footprint of the facility during 2015 for the purpose of obtaining hydrogeological information.

The Chandler Formation is encountered between 755 and 811 metres below ground level. The Halite formation is up to 300 metres thick in places (Tellus exploration borehole CH001A). It occurs as an extensive evaporite unit comprising anhydritic siltstone to 825m and halite below that. Core from boreholes CH001A and CH003 show the salt to be almost pure halite (yellow to red brown, transparent and glassy) with very few marly beds (siltstone and claystone) or other impurities. The unit was formed when a relatively shallow water basin was repeatedly flooded and then subjected to subsequent evaporation, resulting in the deposition, desiccation and precipitation of evaporites (Coffey 2012).



TELLUS

Chandler Facility Stratigraphy

Groundwater Assessment

The Chandler Facility would be located in the upper part of the Chandler salt formation. The upper halite bed in borehole CH001A is present in the depth interval 825 metres to 861metres (Joint Ore Reserves Committee (JORC) report (ERCOSPLAN 2014)). It is overlain by siltstone and underlain by a 10 metre thick bed of limestone/siltstone. Below this bed, the formation is dominantly halite with minor limestones and siltstones. Interpretation of the seismic data at this depth has identified the extent of the salt horizon and suggests that it is stable (i.e. the salt does not appear to be subject to any dissolution in the recent past and it is not migrating (RPS 2013)).

The target horizon is 35 metre thick in borehole CH001A and 34 metres thick in borehole CH003 (and at a slightly shallower depth in CH003). The facility is designed to allow for 20 metres of intact salt above the excavations, which implies that the facility would be at a depth of approximately 850 metres.

Overlying the Chandler Formation are deposits of siltstones and sandstones associated with the Pertaoorrta Group (Giles Creek Formation and Jay Creek Sandstone Formation), Larapinta Group (Stairway Sandstone Formation), Finke Group (Horseshoe Bend Shale Formation and Langra Formation) and the Idracowra Sandstone Formation (see Figure 8-4). Exploration drilling has characterised the overlying geological formations as follows (from shallow to deep):

- **Idracowra Sandstone Formation**: a kaolinitic sandstone that caps the Maryvale Hills across the Chandler Facility area and has a maximum thickness of 40 metres.
- **Horseshoe Bend Shale Formation**: a massive, red brown siltstone/very fine grained, soft to firm quartz sandstone with moderate mica. Contains occasional beds (up to 1 metre thick) of light brown, fine grained sandstone.
- **Langra Formation:** subdivided into three members: the upper, a very fine to coarse light brown sandstone; middle, a mottled red brown siltstone; and lower, a pale brown to orange very fine to fine sandstone with interbedded siltstone. The base of Langra formation is approximately 340 metres below ground level.
- **Stairway Sandstone:** a white coarse to medium grained sandstone with interbedded siltstone and minor shale. The base of the Stairway Sandstone is approximately 500 m below ground level.
- **Jay Creek Sandstone Formation:** comprises upper layers of siltstone with thin interbeds of dolomite and minor fine grained sandstone, and lower layers of shale, and laminated claystone and siltstone (Ride Consulting 2015). The base of the Jay Creek Formation is approximately 770 metres below ground level.
- **Giles Creek Dolomite Formation**: a fine-grained, massive, yellow-brown dolomitic limestone unit, with minor shale bands.

Underlying the Chandler Formation is the Pertatataka Formation (see Figure 8-4), a siltstone and shale formation with lenses of sandstone, dolomite, limestone and conglomerate (Bureau of Mineral Resources, Geology and Geophysics 1968).

To the south of the Proposal the overall formation deposition is mostly flat lying with localised deformation. West of the Proposal, associated with the Charlotte Ranges, is a major anticline, which causes the formations encountered at the Chandler Facility to dip towards the south-east. To the north-east of the Proposal, near the Hugh River, the geology is again deformed as it tilts upwards in what is assumed to be another major anticline.

8.3.3 Regional Hydrogeology

As described in Section 8.3.1., the geological composition and structure of the Amadeus Basin is highly complex, with the development of local and regional groundwater systems influenced by the complex depositional environment and structure of the area, namely the Alice Springs, James Ranges and Petterman Orogenies (refer to Table 8-1).

There are three main groundwater system types associated with the central and south-eastern NT within the Amadeus Basin, the:

- Mereenie Aquifer System (MAS)
- Fractured rock groundwater systems.
- Near surface sediment groundwater systems.

The extent and groundwater flow and recharge/discharge characteristics of each of these systems is summarised below and described in detail in Appendix P.

Mereenie Aquifer System

In the northern-central part of the Amadeus Basin, near Alice Springs, broad folds define three key aquifer systems, the Hermannsberg Sandstone, Mereenie Sandstone and the Pacoota Sandstone systems (Lloyd and Jacobson 1987). These aquifers are collectively termed the MAS (Jolly et al, 2005), and are associated with sediments deposited in the Carboniferous, Devonian and Early Ordovician periods. The MAS units occur within the Northern Amadeus sub-basin and Orange Creek Syncline, but do not occur within the Chandler Syncline (refer to cross-section A-A' in Figure 8-3).

Fractured rock groundwater systems

South of the Orange Creek Syncline and the Central Ridge (see Figure 8-3), a series of intense folding and faulting generated by the James Ranges and Ollife Range has given rise to the deposition of a series of fractured rock systems, including those within the Chandler Syncline. These are primarily Devonian to Ordovician age with some systems extending to the south-east partially dipping below the Pedirka Basin

Unlike the MAS to the north, groundwater within the fractured rock systems is unlikely to be extensive. Localised faulting and the deposition of claystones and siltstones form leaky aquitards throughout the area are likely to have resulted in the development of less extensive and more localised groundwater systems.

Groundwater storage and flow within these localised systems is likely to be restricted by their thickness and the permeability of the geology. Recharge is thought to occur through infiltration of overlying alluvial stream beds during flood events however, the reduced permeability influenced by the claystone aquitards is likely to restrict recharge to these deeper systems.

Discharge is understood to occur primarily via evapotranspiration and at springs along the Finke River to the south-east of the Proposal. Water quality within the localised groundwater systems is highly variable and generally considered to be brackish to saline (> 1,500 mg/L). The limited recharge and low permeability of the system is thought to contribute to long groundwater residence times, greater mineralisation of the local groundwater systems, and therefore reduced water quality.

Near surface sediment groundwater systems

The local near-surface sediment groundwater systems support the various ephemeral surface drainage features bisecting the Proposal. These surface drainage channels incise the bedrock, allowing sediment to partly fill the channel void and provide a medium for groundwater storage and flow. Sediment is typically characterised as moderately porous, poorly sorted and unconsolidated.

The main developed alluvial systems located across the south-eastern extent of the Amadeus Basin are associated with the Hugh River and Finke River. Recharge to these shallow systems primarily occurs during major flooding events.

Due to the shallow nature of these systems, the majority of natural discharge occurs via evapotranspiration. However, leakage to the underlying weathered bedrock is also expected to occur.

8.3.4 Local Hydrogeological setting

The assessment draws on published literature and field investigations including geophysical surveys and the establishment, testing and monitoring of groundwater levels and quality for the Proposal.

Proposal groundwater monitoring bores targeted the fractured sandstone aquifer present across the south-east of the Amadeus Basin. During the Proposal groundwater drilling campaign, inflows were first intersected in the Horseshoe Bend Shale Formation between 80 and 100 metres below ground level. Subsequent groundwater level monitoring has seen a rise in groundwater levels by up to 25 metres from the water intersections observed during drilling. This indicates the groundwater system is semi-confined with low primary porosity and permeability, and the groundwater level monitored is also considered to be the piezometric surface.

Groundwater flow is interpreted to be via fracture flow (secondary porosity), although some limited groundwater flow through primary porosity may also occur. The fundamental characteristic of fractured rock aquifers is the extreme spatial variability of groundwater occurrence, hydraulic

conductivity and flow (Cook, 2003)[19]. During borehole drilling the lowest water intersections were observed in areas where the geology is fine grained and fractures are assumed to be absent (Ride Consulting 2015). Typically, geological units become more consolidated with depth, which is usually accompanied by less groundwater ingress. However, fracture frequency can also be maintained with depth, as evidenced by overall groundwater ingress increasing with depth during drilling through the sandstone/siltstone units.

Borehole water intersections in the relatively shallow Horseshoe Band Shale Formation were mostly comparable and ranged from 0.2 to 2 litres per second (L/s) (refer to Appendix P cross sectional figures {Ride Consulting 2015}); the highest yields were observed in the north-western extent of the Proposal. The next unit encountered was the Langra Formation, which exhibited a larger range of borehole water intersections, more typical of fractured rock groundwater flow. The average water yield for the upper Langra Formation was 4.2 L/s, the middle Langra Formation was 7.5 L/s and the lower Langra Formation was 11 L/s. A constant rate pumping test was conducted at bore PB1 in the upper Langra within the Chandler Facility area. The low pumping rate achieved (4 L/s) and the limited extent of drawdown (as observed at monitoring bore WT1) indicates that the local groundwater system is likely to have a low transmissivity and a limited extent.

Water yields for the next unit, the Stairway Sandstone, were recorded at two bores (between 15 and 20 L/s). Water yields observed during drilling typically over-estimate the sustainable yield from the Formation. A potential sustainable groundwater yield associated with the Stairway Sandstone is therefore likely to be significantly less and likely no greater than 5 L/s.

The Jay Creek Formation exhibits the potential for groundwater presence within the upper sequences of the Formation, as defined through the estimated porosity measurements of 30 % observed at the Mt Charlotte 1 exploratory bore. The Jay Creek Formation transitions into a calcareous dolomitic unit toward its basal extent, where it overlies the Giles Creek Formation. Groundwater potential is negligible within the extent of this unit, given its massive nature and the limited fracture potential.

The Chandler Formation halite deposit is hydro-geologically isolated from the overlying groundwater systems described above. If the water intersections observed in the overlying sedimentary units were indicative of enhanced aquifer permeability at depth, then associated groundwater flows would be expected to result in dissolution of the Chandler Formation, but there is no evidence for this. Basal shale layers in the Jay Creek and Giles Creek Formations are inferred to form an aquitard, preventing downwards groundwater flow. The uppermost regional aquifer is therefore confined to the sandstone and siltstone fractured units that overly the Chandler Formation.

[19] *A guide to regional groundwater flow in fractured rock aquifers. Seaview Press, Adelaide, South Australia.*

Shallow aquifer mapping

An aquifer mapping survey[20] was undertaken by the proponent in September 2015 and the results analysed by Geo9 Pty Ltd (Geo9, 2015). The full report prepared by Geo9 is presented in Appendix N.

The dataset was used to indicatively model relative hydraulic conductivity using electroseismic tomography. The survey was undertaken within the proposed Mine Infrastructure Area and covered a 500 metre by 500 metre footprint to a maximum depth of about 390 metres below ground level (around 400 metre above the Chandler deposit).

Based on calibration with bore log data, the model results indicate there are three main aquifer zones within the saturated thickness of the sandstone aquifer, predominately between 140 and 350 metres below ground level, with minor small perched groundwater systems existing above the regional water table (inferred to be approximately 90 metres below ground level).

The main aquifer occurrences appear to be located in discrete horizontal zones of relatively high hydraulic conductivity which occur at varying depths throughout the Lower Langra Formation. The predicted zones of elevated hydraulic conductivity, which is a potential indicator of water within a geological unit, are depicted by the 'spikes' shown in Figure 8-5. The results of the shallow aquifer geophysical mapping correlate with bore log data.

The groundwater flow potential of the Horseshoe Bend Shale Formation, Langra Formation and Jay Creek Formation groundwater systems are likely to be dominated by secondary porosity as a result of the consolidated and deformed nature of the local geology (EMM 2016).

Based on the model data, Geo9 inferred that groundwater recharge does not appear to be strongly driven by local infiltration, with the majority of recharge most likely occurring remote to the site. The low hydraulic conductivity observed in shallower zones (less than 140 metres below ground level) and the depth of the piezometric surface (at about 90 metres below ground level) was interpreted to indicate that the near surface is relatively dry with little surface recharge to groundwater locally.

Geo9 concluded that, given the local arid climate and lack of apparent surface recharge, groundwater in the local system is likely to be ancient.

[20] *Electroseismic and electrotelluric principles were used to complete the shallow aquifer mapping.*

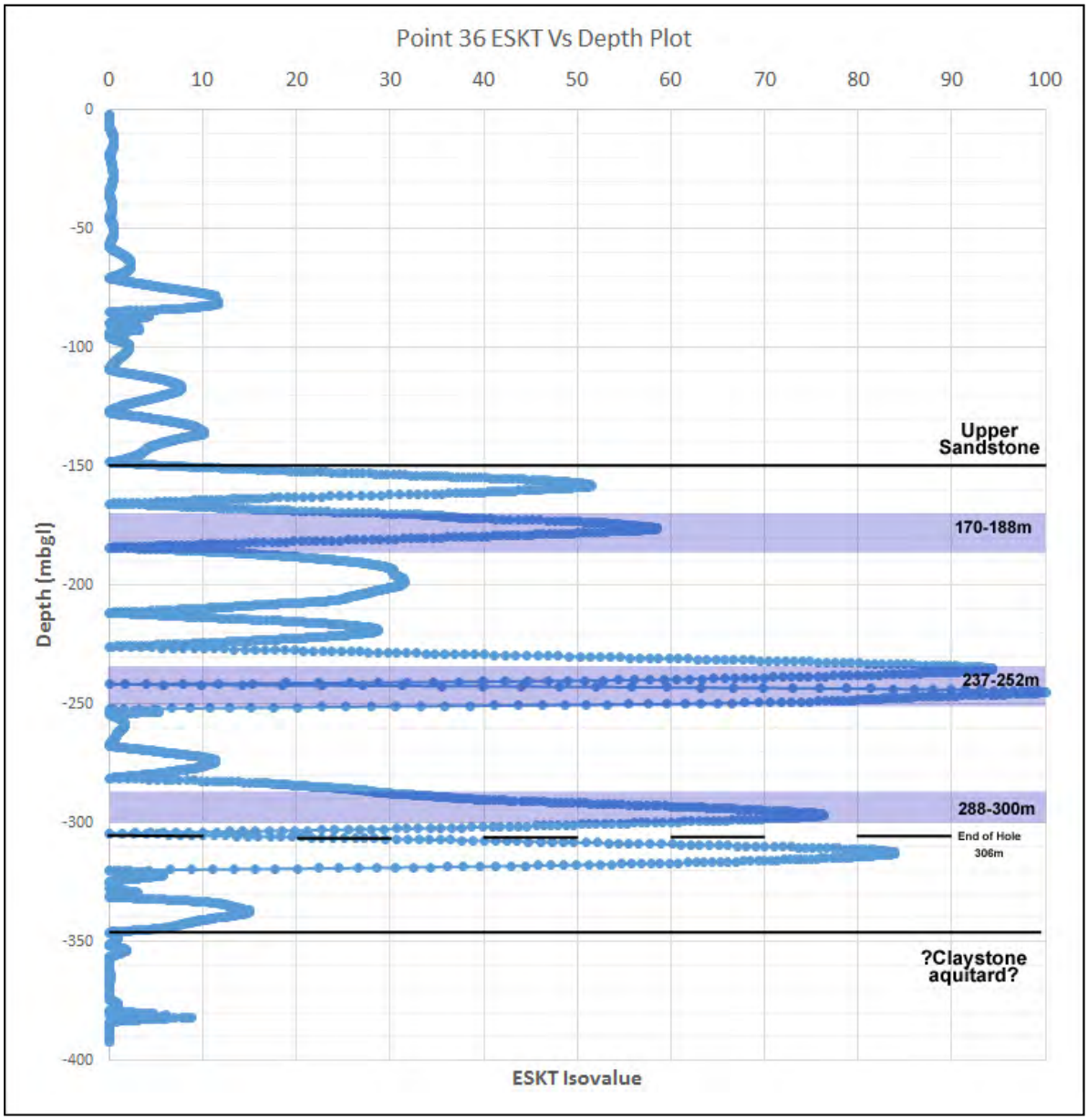


Figure 8-5 Electroseismic hydraulic conductivity tomography across the Proposal area (Geo9 2015)

Groundwater levels and flow

Hydrographs from the Proposal groundwater monitoring bores are presented in Figure 8-6, Figure 8- 7 and Figure 8-8. The hydrographs are plotted against daily rainfall to measure recharge potential within the targeted Horseshow Bend Shale and Langra Formations. The rainfall record comprised a composite dataset from Alice Springs Airport weather station (BoM station 015590) from 1 June 2015 to 6 November 2015, and the local Chandler Facility automated weather station data from 7 November 2015 onwards.

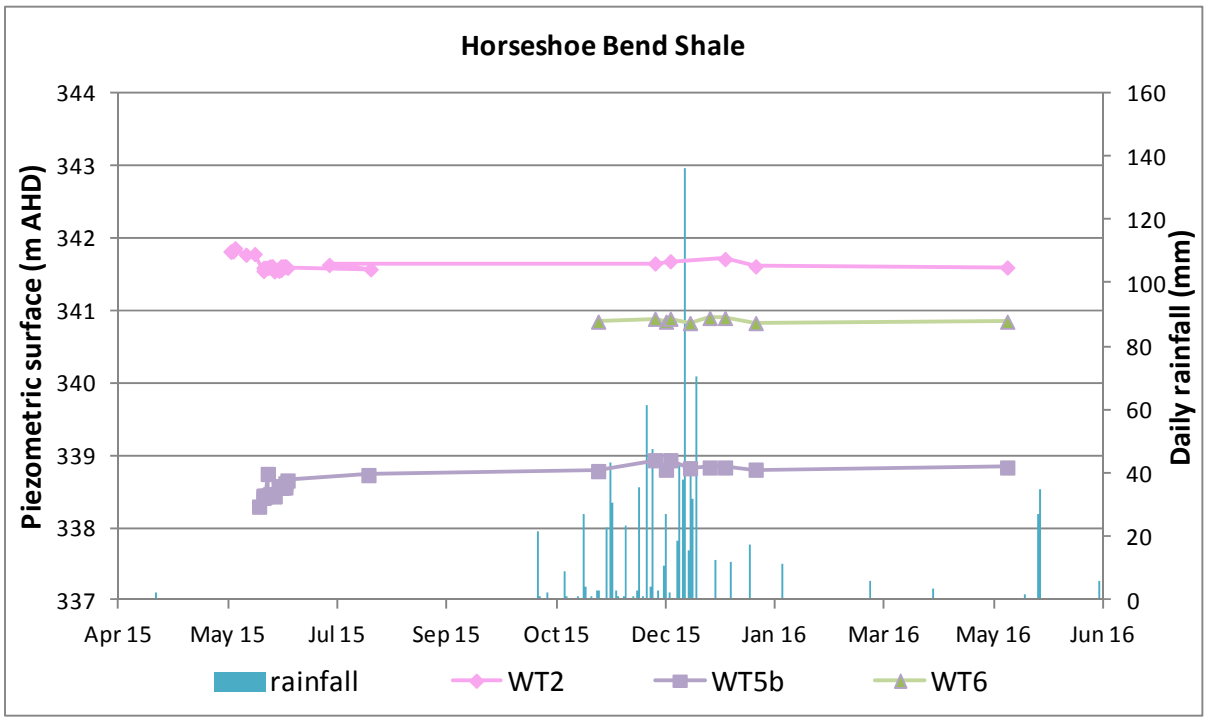


Figure 8-6 **Hydrograph for the Horseshoe Bend Shale Formation**

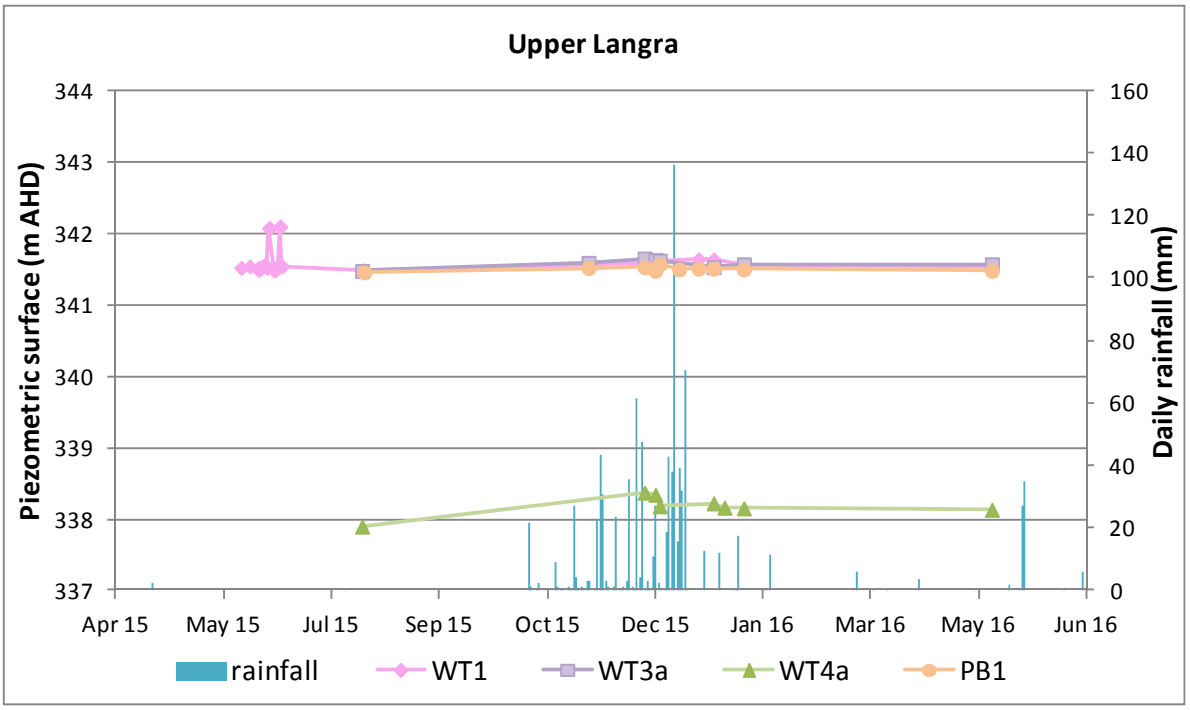


Figure 8-7 **Hydrograph for the Upper Langra Formation**

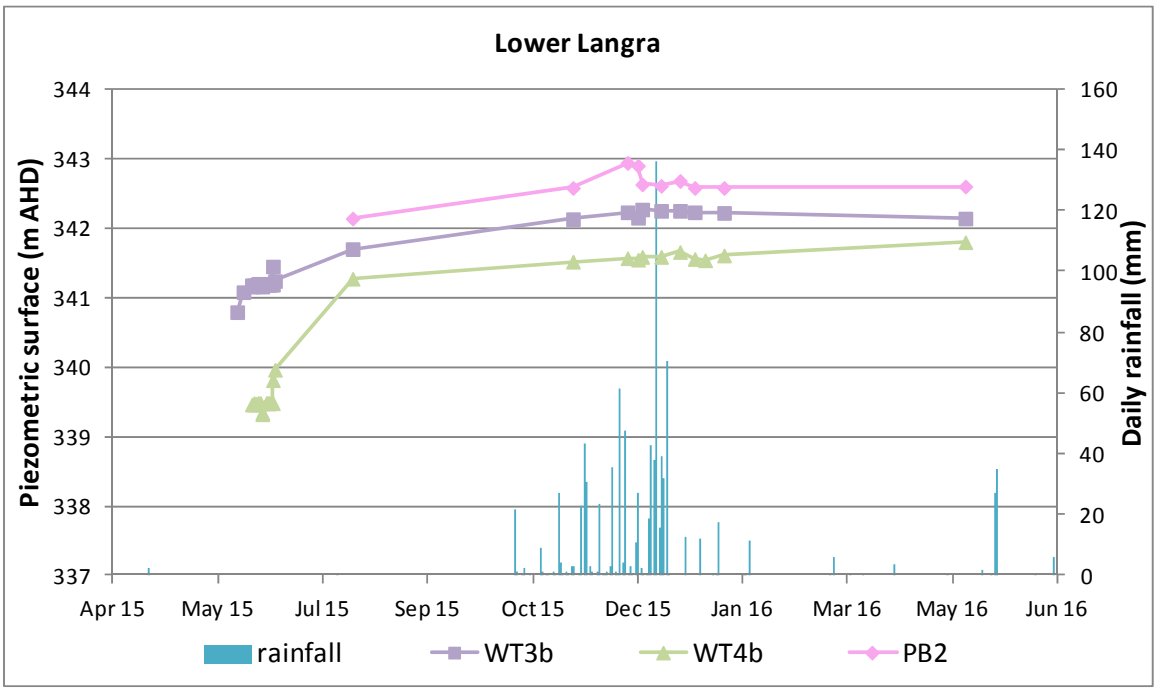


Figure 8-8 **Hydrograph for the Lower Langra Formation**

At the Chandler Facility the piezometric levels for the Horseshoe Bend Shale Formation and Langra Formation (Upper and Lower) are within a 5 metre range, between 338 and 343 metres Australian Height Datum (AHD). Recovery from drilling is relatively slow in the Lower Langra, as seen by the time taken for the piezometric surface to stabilise. This could be indicative of lower permeability and/or storage in this lower formation.

Overall, there is minimal response to rainfall recharge in the piezometric surfaces monitored, indicating the aquifer is dominated by lateral flow rather than vertical flow. In the uppermost formation, the Horseshoe Bend Shale Formation, there is a minor and delayed response (a 0.06 metre rise over 15 days) to rainfall recharge at WT2 and WT6a only.

The hydrographs for the Horseshoe Bend Shale Formation show a decline in piezometric surface (by up to 2 metres) from west to south-east, consistent with the regional groundwater flow direction. The relatively low piezometric surface in WT4b, in the east, compared to the western monitoring bores screening the Lower Langra Formation again confirms the regional west to south-east groundwater flow direction in the deeper unit. Comparable piezometric surfaces in the Upper Langra Formation indicate this unit is more confined than the overlying and underlying groundwater units.

The piezometric surfaces for the Upper Langra Formation are comparable, with the exception of WT4a. The level at WT4a, in the east of the Chandler Facility area, is lower than the piezometric surface at WT4b, targeting the Lower Langra Formation at this location. This indicates an upward vertical gradient within the Langra Formation in this location, likely influenced by local fracturing.

Analysis of the regional groundwater piezometric surfaces indicates that groundwater flows from the west of the Chandler Facility, where it is heavily controlled by topographic gradients, towards

the south-east (refer to Figure 8-9). Beyond the Charlotte Ranges the groundwater flow direction shifts from easterly to south-easterly.

Groundwater recharge and discharge

The main groundwater flow mechanism for the fractured sandstone aquifer is considered to be rainfall recharge to outcropping units to the west and north-west of the Chandler Facility driving lateral flow in the units overlying the Chandler deposit. Secondary recharge is possible through regional through flow to the east and south-east.

As monthly average evaporation exceeds monthly average rainfall by up to 11 times, recharge is event-based and episodic, occurring only during high rainfall events that cause flooding of the overlying local alluvial groundwater systems adjacent to watercourses.

However, across the mine infrastructure area, groundwater level changes were observed to be muted or negligible in response to rainfall as indicated by observations and records at each groundwater monitoring bore.

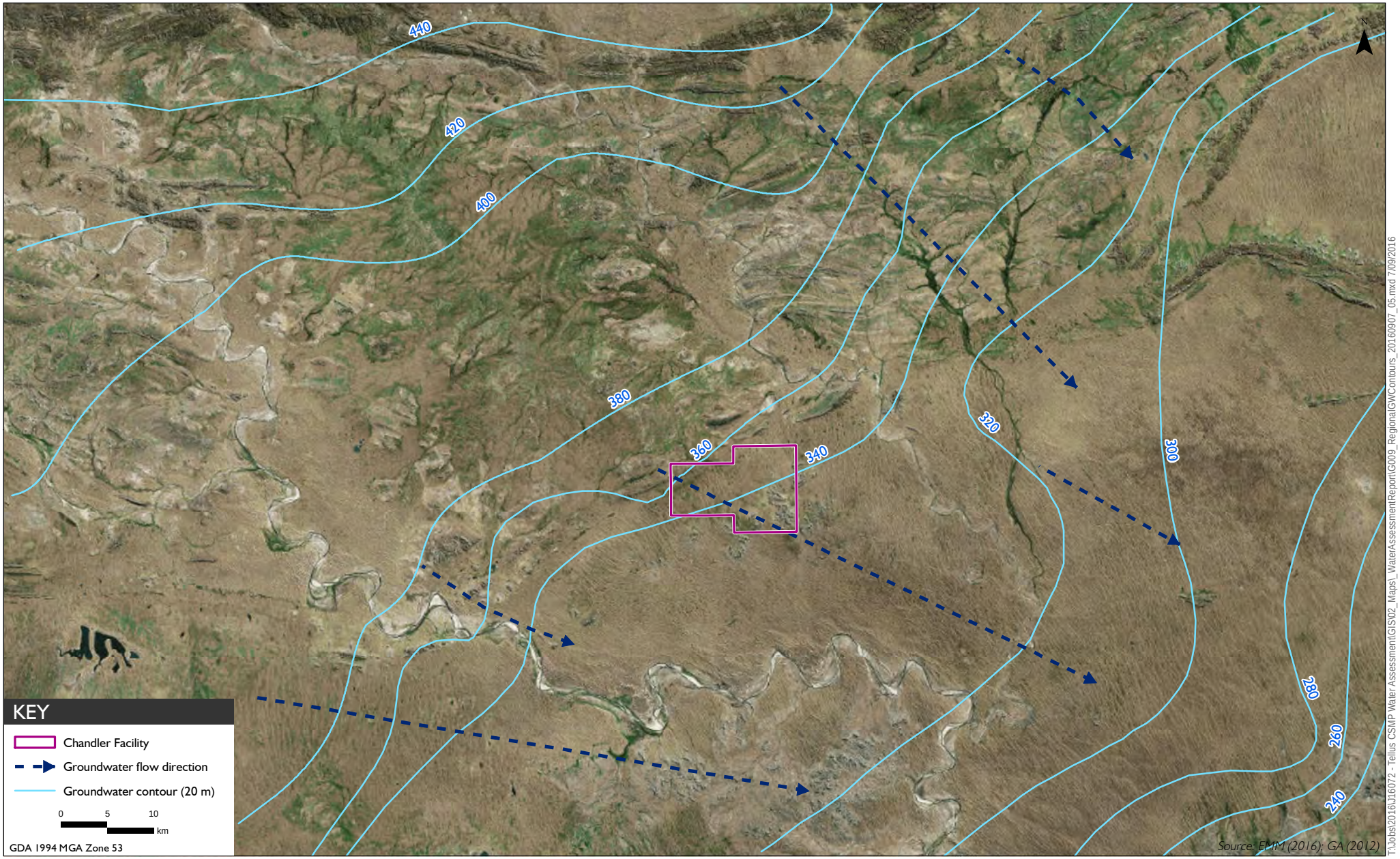
Relic flat basins to the west of the Proposal area are interpreted to have been historic areas of discharge. However, discharge now occurs to the east to the northern Eromanga Basin (Lloyd and Jacobson 1987). This is considered consistent with the regional groundwater flow direction observed from the Proposal groundwater monitoring bores and the standing water levels within regional landholder bores.

On the downstream hydraulic gradient of the proposed Chandler Facility, five groundwater springs are observed to be discharging at the banks of the Finke River to the south and south-east. These include Horseshoe Bend Spring, Black Hill Spring, Polly's Spring, Micks Soak and Pascoes Spring. All springs other than Pascoes Spring (c. 20 km south) are located greater than 50 km south-east of the Chandler Facility and are likely to be discharging from the shallow alluvial groundwater system, which would not be intercepted by the Proposal.

The groundwater flow direction at the Horseshoe Bend Spring location is oriented west/east, whereas the flow from the Proposal area is oriented north-west/south-east. This indicates that groundwater discharges at the Horseshoe Bend spring area are likely to be sourced from a separate groundwater system to the south of the Finke River.

Groundwater quality

Groundwater quality results collected between May 2015 and May 2016 are presented as an average for each sampling location in the Groundwater Assessment (Appendix N).



EMM

Regional groundwater contours

Chandler Salt Mine Project
Water Assessment

Figure 8.9

The groundwater quality results are reasonably comparable between the different target Formations. The groundwater is slightly alkaline (averaging pH 8) and saline (electrical conductivity ranged between 12,600 and 21,000 microSeimens per centimetre (µS/cm)).

The water type at all locations was dominated by sodium and chloride, with minor calcium and sulfate ions. Total iron and zinc measurements were typically two to three orders of magnitude higher than the other total metal analytes.

Regional water quality monitoring conducted by the NT Government indicates that salinity is comparable (ie moderately saline) for other monitoring locations targeting the Langra Formation. Regional mean electrical conductivity (11,307 µS/cm) is slightly lower than observed within the proposed Chandler Facility area but remains within a saline category. Regional monitoring in the Stairway Sandstone, underlying the Langra Formation, has comparable pH and electrical conductivity results (mean electrical conductivity: 16,578 µS/cm) to the Langra Formation at the Chandler Facility. Regional water type for the Langra Formation and Stairway Sandstone is also dominated by sodium and chloride. The water is generally suitable only for industrial uses.

It is important to note that:

- All the aquifers (Horseshoe Bend Shale, Upper Langra, Lower Langra and Stairway Sandstone) contain water with salinity significantly in excess of the salinity of potable water. Were water from these aquifers to be used for human consumption it would need to be diluted to < 1000 mg/L and more likely < 6 00 mg/L (e.g. WHO 2011).
- The highest salinity groundwaters occur in the Stairway Sandstone (approximately 15,000 mg/L). The Jay Creek Formation (approximately 40,000 mg/L) and the underlying Gillen Member (of about 318,000 mg/L).
- The highest salinities are all less than any water that is saturated with respect to (in equilibrium with) halite. Such a water at 25 °C would equal about 360,000 mg/L.

If any of these groundwaters were to be used in future for human consumption or for agriculture, they would need to be diluted significantly on account of their high salinity. This dilution would also reduce the concentrations of any contaminants that could potentially mobilise in the groundwater systems through construction, operational, or post closure activities (which is assessed to be very unlikely, refer to Section 8.6.2).

The relatively low salinity of the groundwater within the upper part of the Chandler Formation is very unlikely to be due to upwards flow of halite solute because:

- Such a process would be expected to result in dissolution of the halite in the upper part of the Chandler Formation, for which there is no evidence (e.g. RPS 2012).
- On lithological grounds the upper part of the Chandler Formation is interpreted to have very low permeability, inhibiting rapid groundwater flow.

- Groundwater fluxes are interpreted to be very slow, based on the low interpreted rates of recharge and low hydraulic gradients.

In view of these points, the steep salinity gradient that must exist between the top of the Chandler Halite and the upper lithologies (Horseshoe Bend Shale, Upper, Middle and Lower Langra, and Santo Sandstone) where groundwater samples were obtained, implies that if natural transport of solutes did occur in an upwards direction from the Chandler Halite, it must be extremely small (i.e. it has no material effect on the salinity of the overlying formations).

Similar arguments to these also support the conclusion that any natural fluxes of groundwater and solutes upwards from the Chandler Formation to the Stairway Sandstone Formation must be very small.

The density contrast between the deeper saline water near to the Chandler Halite and the shallower, less saline water within the overburden would also tend to act against upwards flow of groundwater. For example, the salinity of the water in the Stairway Sandstone implies a density of about 1,015 kg/m^3. In contrast, water in the Chandler Formation that has dissolved halite to the point of saturation would have a salinity of about 360,000 mg/L, equivalent to a density of about. 1,360 kg/m^3.

Water use - Landholder bores

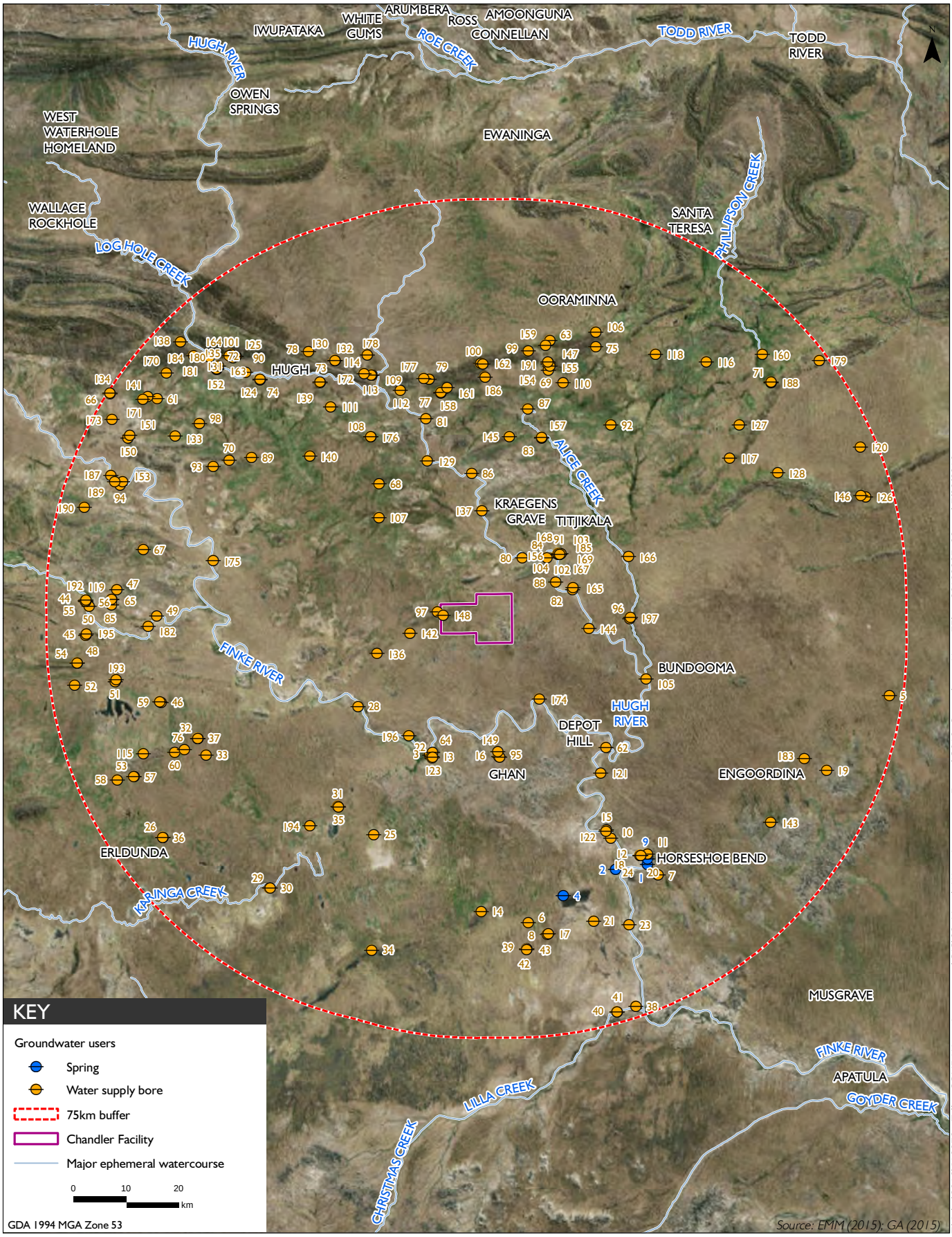
The Amadeus Basin hosts numerous groundwater supply bore fields across central and south-eastern NT. Regionally, the Roe Creek and Rocky Hill Borefield, located approximately 100 km north of the Proposal provide the potable supply to Alice Springs. Both bore fields are located within the Orange Creek Syncline and target the Mereenie Aquifer System which is distinctly separate to the Chandler Syncline system.

Elsewhere, closer to the Proposal and within the south-east extent of the Amadeus Basin, numerous landholder bores target the shallow near-surface sediment groundwater systems along the Finke and Hugh Rivers. Other bores target deeper groundwater within the Idracowra and Stairway Sandstone.

A search for landholder bores registered for ‘production’ has been undertaken. A 75 kilometre and 25 kilometre spatial buffer around the Chandler Facility was prepared (refer to Figure 8-10 and Figure 8-11).

Landholder bores located within the 25 kilometre spatial buffer have been tabulated in the Groundwater Assessment (Appendix P). Also included in Appendix P are groundwater levels, predicted flow direction and interpreted water quality from these bores as well as a complete list of bores located within the 75 kilometre spatial buffer.

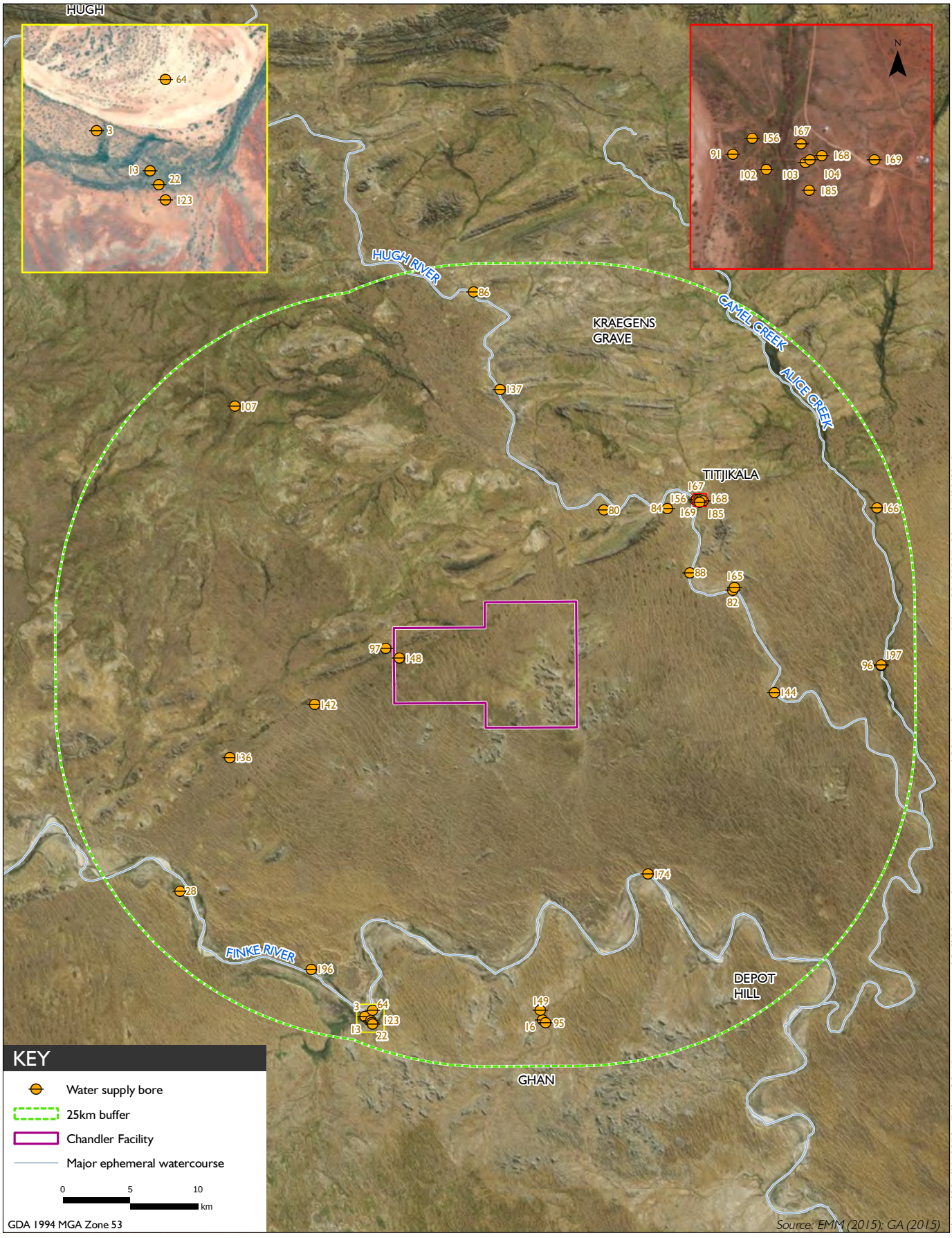
In total, 36 landholder production bores were identified within the 25 kilometre spatial buffer (including the Titjikala groundwater bore) and 193 were identified within the 75 kilometre spatial buffer.



T:\Jobs\2016\J160072 - Tellus CSMP Water Assessment\GIS\02_Maps_WaterAssessmentReport\G013_GroundwaterUsers75km_20160907_03.mxd 7/09/2016

Groundwater users within 75 km of the project area

Chandler Salt Mine Project
Water Assessment
Figure 8.10



T:\Jobs\2016\J16072 - Tellus CSMP Water Assessment\GIS\02_Maps_WaterAssessmentReport\G014_GroundwaterUsers25km_20160907_03.mxd 7/09/2016

EMM

Groundwater users within 25 km of the Chandler Facility

Chandler Salt Mine Project
Water Assessment
Figure 8.11

The groundwater levels within the 25 kilometre spatial buffer were mostly relatively shallow with a range between 6.44 and 18.4 metres below ground level. It is noted that landholder bores are generally located in lower lying creek lines and areas of the landscape that typically intercept localised groundwater in alluvial/colluvial sediment and weathered bedrock (i.e. Idracowra Sandstone and Stairway Sandstone).

Elsewhere, for bores targeting the deeper groundwater associated with the Stairway Sandstone, groundwater levels ranged between 31 and 88.4 m below ground level (shallow by comparison with the Chandler Formation at 800 m below ground level).

Groundwater levels, once converted to a common elevation datum ranged between 409.9 metres AHD and 306.6 m AHD, which demonstrates a wide range of about 100 metres. The shallower level (306.6 m AHD) measures the piezometric surface within the Stairway Sandstone down hydraulic gradient along the eastern boundary of Alice Creek. The higher level (409.9 m AHD) is measured to the west of the proposed Chandler Facility along the Charlotte Range.

The shallowest levels were observed at Top Soak Bore–RN12534 (5.2 m below ground level) along the southern boundary of the ephemeral Finke River at an elevation of 345.1 metres AHD. The inferred geology at this location comprised shallow Cainozoic alluvials underlain by Idracowra Sandstone.

Groundwater quality results, where available, for the landholder bores indicate the groundwater conditions within the shallow local groundwater systems are highly variable, ranging from fresh (bores targeting the shallow Titjikala aquifer) to saline (bores targeting the deeper Stairway Sandstone and the Idracowra Sandstone).

The major ion chemistry of the shallow (< 20 m deep) and deep landholder bores (> 20 m deep) within the 25kilometre spatial buffer displayed highly variable water types. The majority of shallow landholder bores targeting the alluvium and tertiary sediment were dominated by calcium, chloride and bicarbonate, whereas water types within the deeper landholder bores targeting the Stairway Sandstone, Idracowra Sandstone and Titjikala aquifer were more closely associated with sodium, chloride and bicarbonate.

Springs

Five groundwater springs are located within a 75 kilometre radius of the Chandler Facility (Figure 8- 12), the nearest (Pascoes Spring) being approximately 20 kilometre south-west of the proposed Chandler Facility. The remaining four springs (Horseshoe Bend Spring, Black Hill Spring, Polly's Spring, and Micks Soak) are all located approximately 50 kilometre south-east of the Chandler Facility, situated along the Finke River.

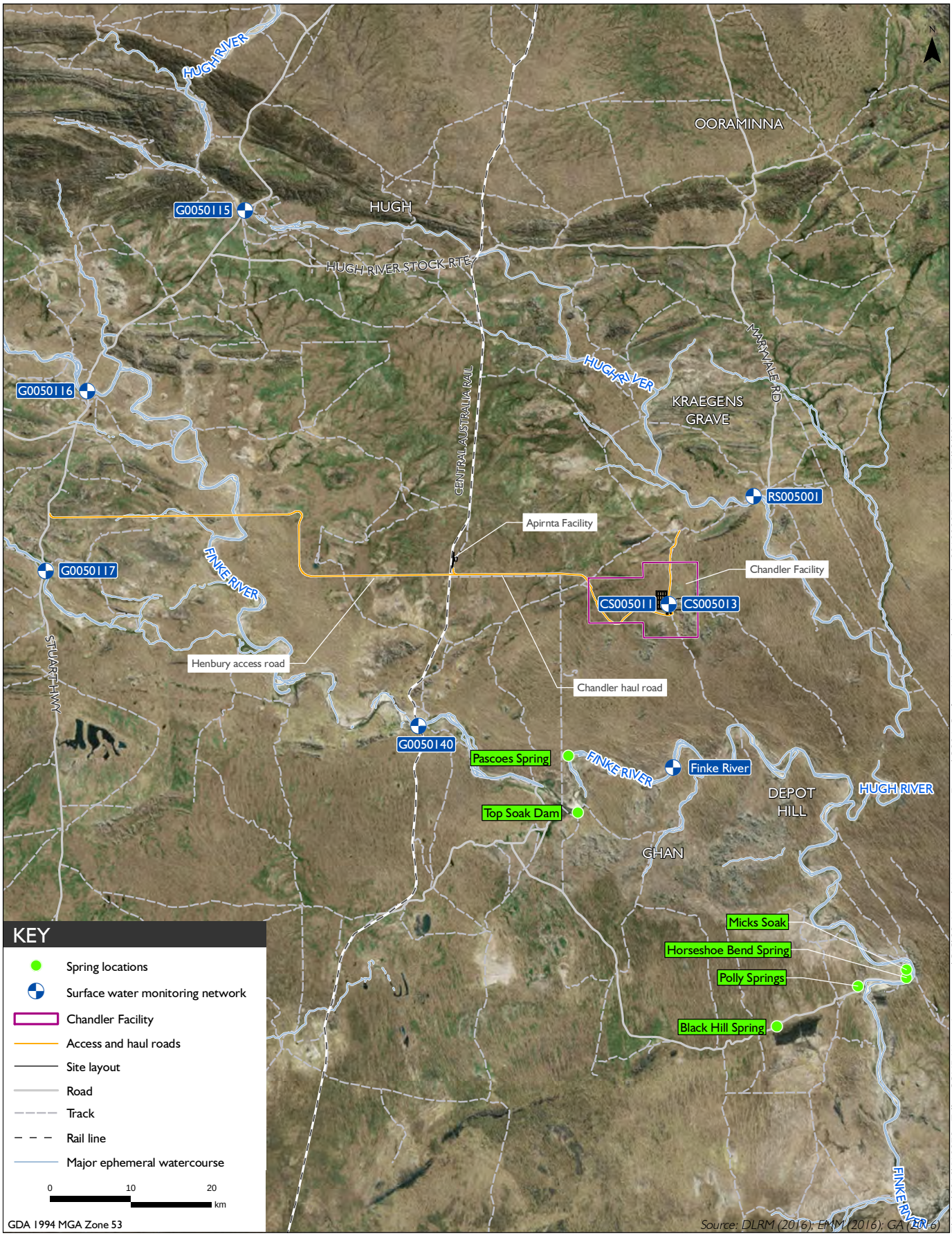
Riparian vegetation communities consisting predominantly of River Red Gum and Coolabah are likely to be partially sustained through intermittent baseflow provided by these four groundwater springs. However, the majority of water sustaining these ecological communities is thought to be provided through flooding events.

Approximately 230 kilometres south-east of the Chandler Facility the Dalhousie Spring complex emanates in an area underlain by the Lake Eyre Basin, western Eromanga Basin and the Pedirka Basin, but beyond the south-eastern boundary of the Amadeus Basin. The Dalhousie Spring complex is considered in the Groundwater Assessment as it is an important ecological and cultural asset. The Dalhousie Spring complex is attributed as a discharge feature of the Eromanga Basin and is also supported in part by discharge from the Crowne Point Formation, a key groundwater system within the Pedirka Basin (Wohling et al, 2013). There is no evidence for any hydraulic connectivity with the Amadeus Basin or the Chandler Syncline sub-basin.

Groundwater dependant ecosystems

Two ecological communities (Eucalyptus camaldulensis var. Obtuse and Eucalyptus coolabah subsp. Arida) have been identified by DLRM to persist within the riparian corridors of the Finke and Hugh Rivers. These communities are commonly identified in the Bureau of Meteorology's Atlas of Groundwater Dependent Ecosystems (BoM 2016) as having a moderate potential for groundwater interaction. The root structure is considered to be shallow (less than 15 metres) and may potentially receive a source of water from perched shallow groundwater systems (i.e. alluvial sources) associated with ephemeral creeks. Neither of these ecological communities has been listed as endangered ecological communities.

A complete list of key sensitive groundwater receptors identified during the desktop study, their source of water and the potential impact are listed later in this Chapter (Table 8-5).



Surface water monitoring network

Chandler Salt Mine Project

Water Assessment

Figure 8.12

8.4 Site conceptual model

This section presents the site conceptual (hydrogeological) model of the proposed development footprint and vicinity. A conceptual (hydrogeological) model is a simplified representation of the physical hydrological and hydrogeological setting and understanding of the system. This includes the identification and description of the geologic and hydrologic frameworks, recharge to the system, groundwater flow dynamics and surface-groundwater interaction processes.

The model is used in subsequent sections of this chapter to describe potential sources, pathways, receptors, and fate of any potentially contaminated waters from the Proposal.

8.4.1 Groundwater systems

The Proposal area is within the Chandler Syncline (sub-basin) located within the south-eastern extent of the Amadeus Basin. The Chandler Syncline hosts various local groundwater systems, all of which have minor confining layers and permeability barriers to groundwater flow. The basal unit overlying the target salt resource of the Chandler Formation is the Giles Creek Dolostone Formation, comprising predominantly dolomitic calcareous shales and sand and silt sediment. The Giles Creek Dolostone is an aquitard, unsaturated, and acts as a barrier to groundwater flow.

Overlying the Giles Creek Dolostone Formation is the Jay Creek Limestone Formation, comprising predominantly of marine shale, silt and sand sediments and thin beds of dolomite. The Jay Creek Formation is a potential water bearing zone.

Overlying the Jay Creek Limestone Formation is the Stairway Sandstone Formation, a thick geological sequence comprising predominantly continental coarse to medium grained sandstone within interbedded minor silt and shale beds. The Stairway Sandstone is a water bearing zone and supports numerous landholder bores within the region at shallow depths (<100 metres below ground level).

Overlying the Stairway Sandstone Formation is the Langra Formation, a geological unit subdivided into three member units, represented at depth by interbedded silt and shale beds, gradually transitioning into extensive fine to medium grained sand.

Overlying the Langra Formation is the Horseshoe Bend Shale Formation, a massive siltstone and quartzitic sandstone deposit. Both the Langra and Horseshoe Bend Shale Formations are water bearing zones and contain brackish to saline groundwater.

Directly above the Horseshoe Bend Shale Formation and partially eroded at surface across the Proposal area is the Idracowra Sandstone, a kaolinitic sandstone represented across the Maryvale Hills and discontinuous across the Proposal area. The Idracowra Sandstone supports numerous groundwater users within a 25 km radius of the Proposal. Groundwater is typically saline and as such is used locally as a stock supply. The Idracowra Sandstone Formation would not be intercepted by the Proposal mining.

Locally in the vicinity of the Proposal area, there is limited recharge from direct rainfall and minor recharge is expected to occur via infiltration from overlying alluvial systems during major flooding

events. Minor direct rainfall recharge may occur locally, but the low rainfall and high evaporation means this volume would be minimal and the presence of stratified low permeability clays and silts in the middle and lower members of the Langra Formation is likely to result in the formation of perched localised groundwater systems in the upper Langra Formation and Horseshoe Bend Shale Formation.

The inferred piezometric surface ranges between 60 and 90 metres below ground level across the Chandler Facility.

Consistent with topographic gradients, hydraulic gradients are very gentle in the south-eastern extent of the Amadeus Basin, and the broad flow direction in all groundwater systems is generally from north-west to south-east.

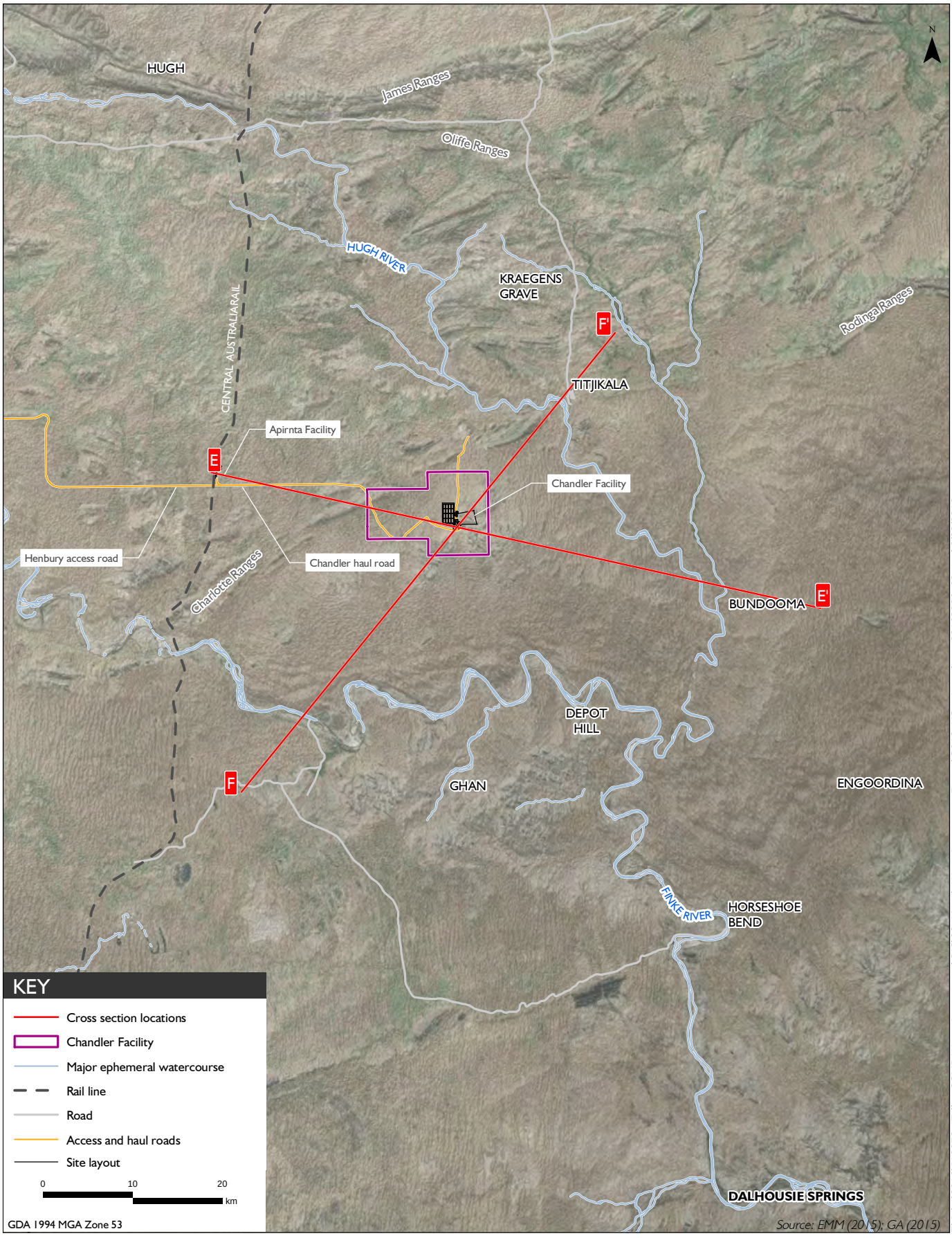
Two cross sections were drawn across the Chandler Facility (refer to Figure 8-13). The basement structure (typically associated with folding) influences the groundwater flow direction in certain areas. The horizontal hydraulic conductivity in geological units is highly variable, due to the depositional environments and volume of clay; substantial lateral flow through formations is therefore not expected.

There is an upwards hydraulic gradient from the Langra Formation to the Horseshoe Bend Shale Formation based on pressure head differences observed through groundwater monitoring, but there is no evidence of substantial flow volumes between these units. Elsewhere, within the 25 kilometre spatial buffer around the Chandler Facility, landholder bores located within the shallow alluvium report shallow groundwater levels which are likely to be perched systems, with very little connectivity to the underlying Idracowra Sandstone Formation and Horseshoe Bend Shale Formation.

The saline groundwater quality within the Chandler Syncline differs markedly from the potable water quality reported for the Mereenie Aquifer System about 100 kilometres north within the Northern Amadeus Basin.

The Chandler Syncline system is a separate groundwater system entirely and therefore, not connected to the groundwater sources utilised for the Alice Springs Water Supply. The evidence confirms that the Chandler Syncline system is distinct and separate from the Mereenie Aquifer System in terms of geological structure, lithological units, groundwater flow properties, hydraulic gradients and hydro-geochemistry.

Water quality within shallow alluvial groundwater accessed by landholder bores to the north and west of the Chandler Facility, particularly at Titjikala, is potable. By comparison, groundwater quality observed within the Horseshoe Bend Shale and Langra local groundwater systems at the Chandler Facility is poor and saline. Salts originating from the marine depositional environment, and the enhanced climatic nature of the environment (i.e. low precipitation/high evaporation), coupled with long groundwater residence times is likely to contribute to the poor groundwater quality observed within the Chandler Syncline.



EMM

Location of the cross-sections

Chandler Salt Mine Project
Water Assessment

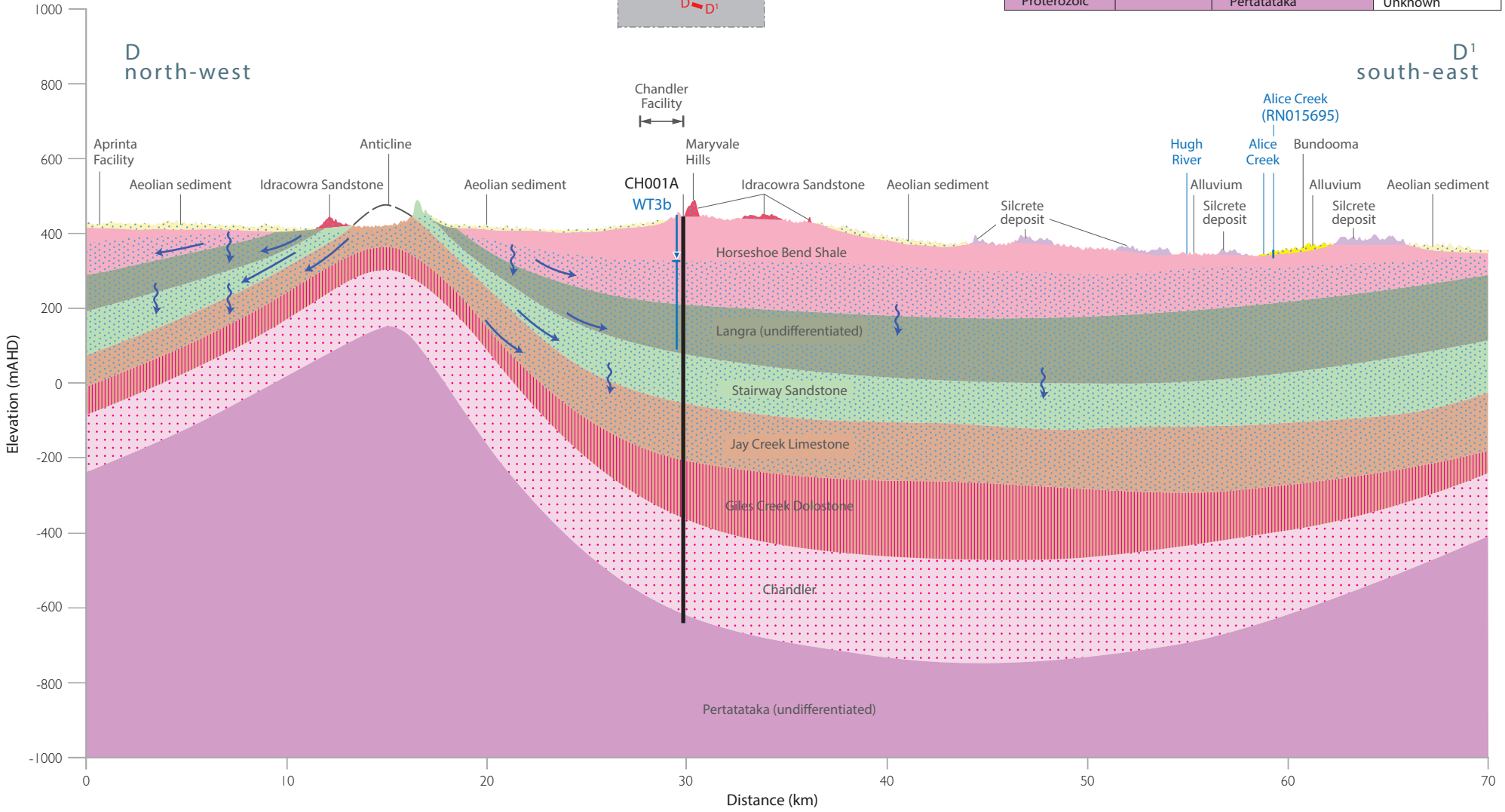
Figure 8.13

TELLUS



Water bore
Exploration bore
Piezometric surface
Saturated zone
Groundwater flow

Age	Group	Formation	Hydrogeology
Quaternary		Alluvium	Aquifer (perched)
		Aeolian sediment	Aquifer (perched)
Tertiary		Silcrete deposit	Aquitard (local)
Carboniferous		Idracowra Sandstone	Aquifer
Devonian			
	Finke	Horseshoe Bend Shale	Aquifer
		Langra	Aquifer
Ordovician	Larapinta	Stairway Sandstone	Aquifer
Cambrian	Pertaoorrta	Jay Creek Limestone	Aquifer
		Giles Creek Dolostone	Aquitard
		Chandler	Aquitard
Proterozoic		Pertatataka	Unknown

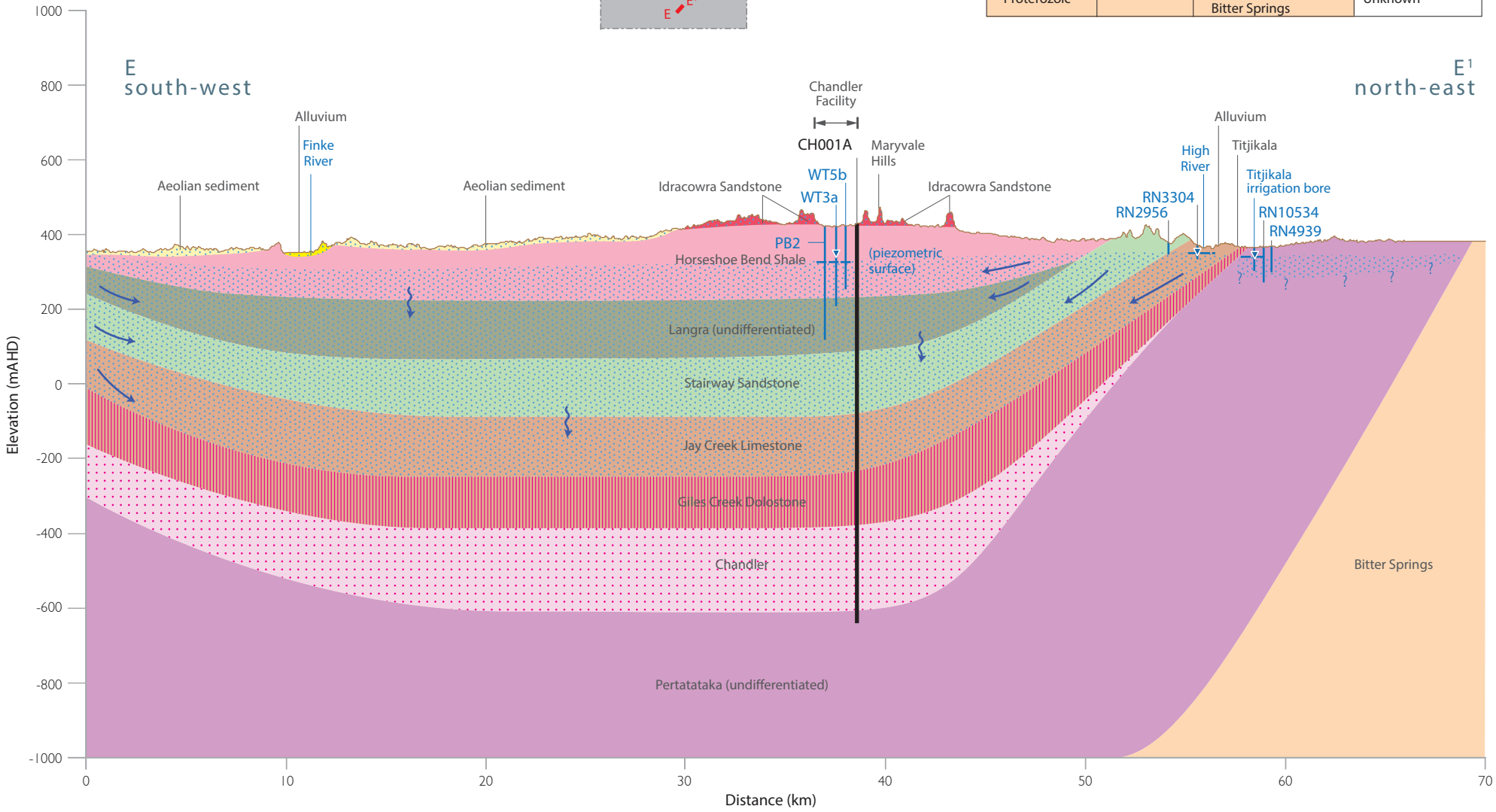


TELLUS



Water bore
Exploration bore
Piezometric surface
Saturated zone
Groundwater flow

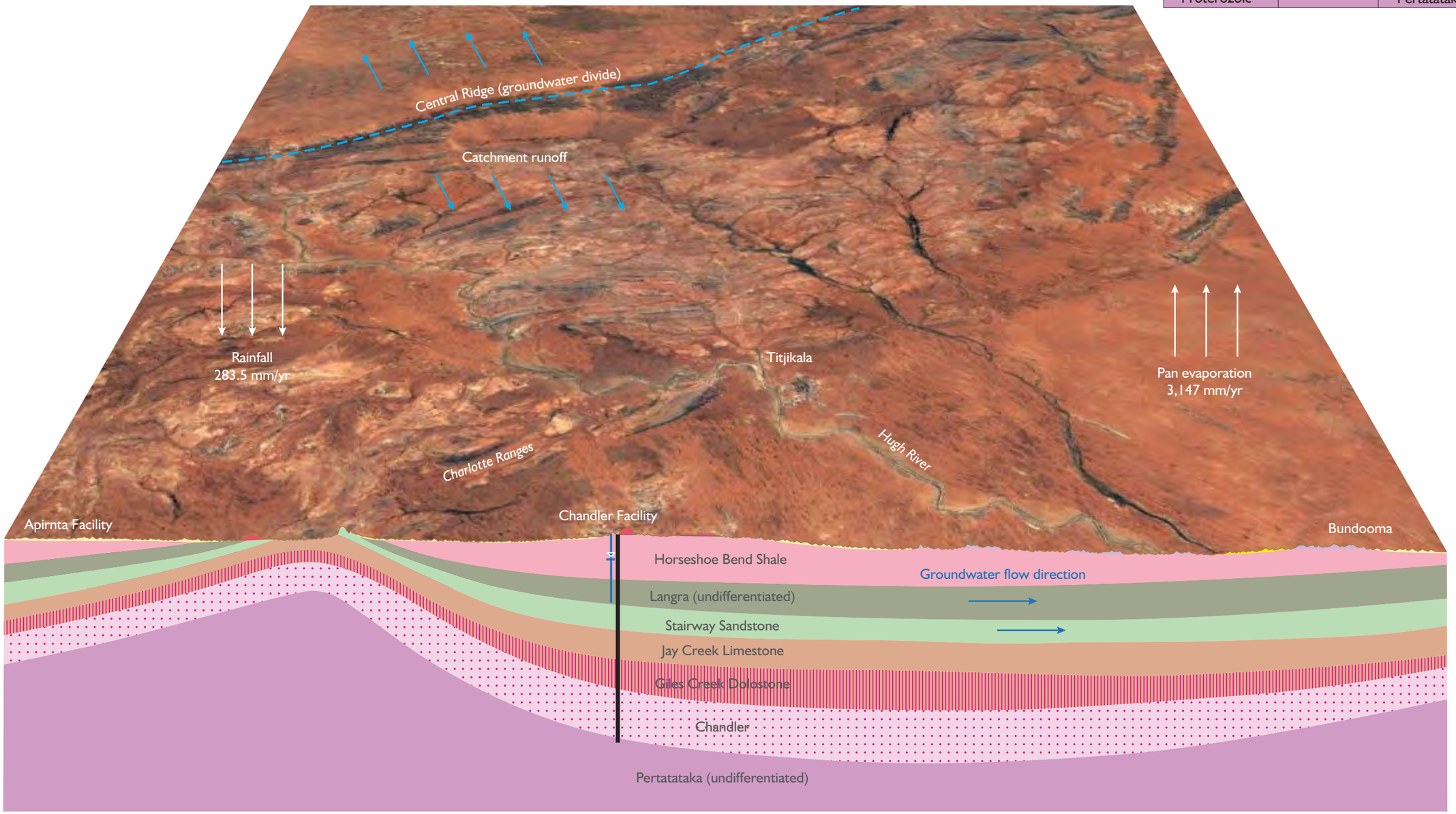
Age	Group	Formation	Hydrogeology
Quaternary		Alluvium	Aquifer (perched)
		Aeolian sediment	Aquifer (perched)
Tertiary		Silcrete deposit	Aquitard (local)
Carboniferous		Idracowra Sandstone	Aquifer
Devonian			
	Finke	Horseshoe Bend Shale	Aquifer
		Langra	Aquifer
Ordovician	Larapinta	Stairway Sandstone	Aquifer
Cambrian	Pertaoorrta	Jay Creek Limestone	Aquifer
		Giles Creek Dolostone	Aquitard
		Chandler	Aquitard
Proterozoic		Pertatataka	Unknown
		Bitter Springs	



EMM

Water bore
Exploration bore
Piezometric surface

Age	Group	Formation
Quaternary		Alluvium
		Aeolian sediment
Tertiary		Silcrete deposit
Carboniferous		Idracowra Sandstone
Devonian		
	Finke	Horseshoe Bend Shale
		Langra
Ordovician	Larapinta	Stairway Sandstone
Cambrian	Pertaoorrta	Jay Creek Limestone
		Giles Creek Dolostone
		Chandler
Proterozoic		Pertatataka



8.4.2 Surface water and groundwater connectivity

The widespread absence of permanent surface water features across the Proposal area indicates that the groundwater and surface water systems are not connected in the vicinity of the Chandler Facility or the Apirnta Facility. However, shallow groundwater levels and gradients within the alluvium groundwater system indicate some potential for connectivity to the south-east along the Finke River about 20 km from the Chandler Facility.

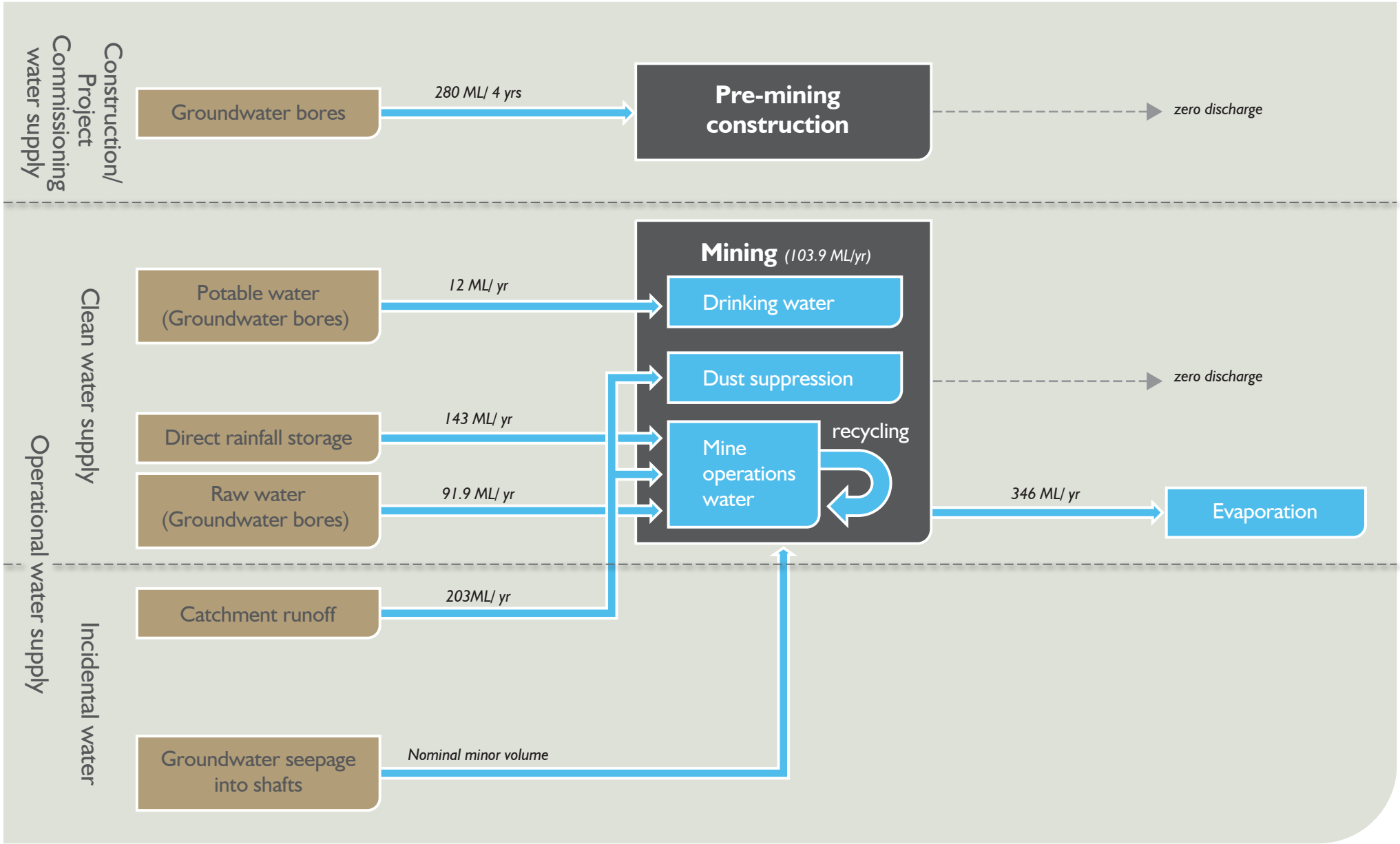
It is difficult to at this stage to gain a comprehensive understanding of connectivity in areas along the Finke River as there are no groundwater monitoring bores located directly adjacent to the Finke River and screened within the deeper groundwater systems (i.e. Idracowra Sandstone, Horseshoe Bend Shale or Langra Formation). However, characterisation of the water type of the springs located along the Finke River to the south and south-east of the Chandler Facility suggest the source of water from these springs is likely to be derived from the perched shallow alluvial sediment and not the deeper groundwater system connected to the Chandler Facility approximately 50 km away. This implies a lack of connectivity, which would mean that any potential drawdown impacts in the deeper groundwater systems arising from Proposal dewatering through abstraction or mining activities would not impact surface water resources.

It should also be noted that the drawdown impacts arising from the Proposal would be of such low magnitude and extent that they would not reach the spring areas (refer to Section 8.4.3). This is due to the low rate of groundwater pumping throughout the Proposal life (1.7 L/s, which is broadly consistent with stock and domestic rates), and also the limited extent of drawdown due to the relatively low permeability aquifer units, and the intervening aquitard units.

8.4.3 Groundwater modelling of drawdown impacts

The De Glee (1930) analytical model of steady state drawdown in leaky aquifer systems has been applied to investigate the pumping and drawdown relationship, based on site specific hydrogeological data and the site hydrogeological conceptual model. The de Glee model has been used in northern South Australia to investigate the drawdown effects due to extractions in the Eromanga Basin as part of the Far North Water Allocation Plan.

Based on results obtained through the Proposal drilling and monitoring program, a groundwater drawdown rate of 0.2 metres has been calculated at a distance of 1 kilometre from a bore continuously pumping in excess of the project water demand of 1.7 L/s (refer to Figure 8-17).



TELLUS

Water balance schematic

Chandler Salt Mine Project
Water Assessment

This distance drawdown relationship was calculated using the de Glee equation:

$$s_m = Q/(2\pi KD)\ K_0(r/L)$$

Table 8-2 defines the variables used in the above solution.

Table 8-2 Aquifer parameters

Variable ID	Parameter	Unit	Adopted value
s_m	Drawdown and radial distance	m	-
Q	Well discharge	m^3/day [1]	172.8
L	Leakage factor	m	447
c	Hydraulic resistance	~	20,000
D'	Saturated thickness	m	20
K'	Hydraulic conductivity	m/d	0.001
$K_0(x)$	Bessel function	~	0.085

Notes: 1.m^3/day = cubic metres per day

The de Glee analytical modelling method is consistent with the Proposal conceptual model (semi-confined or leaky aquifer conditions). Water take through mine dewatering and groundwater abstraction has been calculated and the result (0.2 metre drawdown) is likely to have a limited and very localised drawdown impact, primarily confined to the defined Project area.

Further detailed analytical interpretation would be completed following the implementation of additional monitoring and pumping tests within stage two groundwater drilling works following approval of the Proposal.

8.4.4 Water balance

A water balance involves the estimation of the storage and flow of water in a defined area, during a given timeframe. A mass balance equation is used in which the change of water stored within an open (natural) hydrological system is equal to the inputs to the system minus the outputs from the system (Todd and Mays 2005):

$$\text{Change in storage } (\Delta S) = \text{Inflows} - \text{Outflows}$$

A water balance combining the mine water management system, abstracted saline and potable groundwater, and saline water intercepted during construction has been prepared for the construction and operations phases.

The water balance is based on the conceptual mine plan and would be updated following the completion of detailed design. The results of the updated water balance would be carried through into the Proposal's Water Management Plan (refer to Appendix O).

The conceptual water balance is presented in Figure 8-18 and indicates marginal net change in total site water inventory during the operation phase.



Table 8-3 Water balance (average rainfall per year)

Parameter	Construction (ML/y)	Operation – Year 1
Inflows to water management system		
Groundwater inflow into shafts	0	0
Catchment runoff	203	203
Direct rainfall on water storage areas	143	143
Raw water supply for processing / dust suppression	54	54
Potable water supply	16	12
TOTAL INFLOW	**416**	**412**
Outflows from water management system		
Net site water management system	70	99
Uncontrolled release	0	0
Evaporation	346	346
TOTAL OUTFLOW	**416**	**445**
Net change in total site water inventory	**0**	**33**

Notes: 1. ML/year = mega litres per year.

The water management system maximises the capture and reuse of mine affected water. The majority of water would be sourced from groundwater abstraction with make-up water supplied via on-site sources (i.e. rainfall runoff). Mine affected water would be reused to the supply the processing plant and water dust suppression demands in addition to groundwater abstraction which would target the Langra and Stairway Sandstone Formations.

8.5 Assessment of risk during construction

This section presents the potential impacts (both direct and indirect) on groundwater during construction of the Proposal. Mitigation measures to avoid or reduce these impacts are discussed in Section 8.8. Changes to groundwater levels, groundwater chemistry and the hydrogeology itself are considered in respect of the sensitive receptors that were identified earlier in Section 8.3. Specifically, the significance of change and subsequent impact is considered.

When considering the potential environmental impacts of the Proposal during development, operation and post operational phases on regional groundwater water resources, the management of natural resources within the study area must be considered.

In respect to potential effects on groundwater, existing land and water resource users within the region have an interest. Where there are no potential adverse effects, individuals, communities, interested organisations and relevant government agencies have an interest in why there are no potential impacts on the water resources in their area, town or community.

This means that the regional area studied must be much larger than the local area in which the Proposal would take place.

8.5.1 Direct impacts

Overview

Direct impacts on groundwater during construction may include groundwater abstraction resulting in localised drawdown. Potential impacts from abstracting groundwater are discussed below.

Groundwater abstraction would service potable and raw water supply demands across the Proposal. A maximum groundwater demand of approximately 70 mega litres per year would be required over the four-year construction/commissioning period.

Groundwater abstraction during construction would service the following primary activities.

- Raw water supply.
- Potable water supply.
- Building the Apirnta Facility.
- Building the Chandler Facility.

Raw water supply

Raw water would be abstracted during construction to service key activities including:

1. Chandler Facility dust suppression, drilling and construction demands.
2. Chandler Haul Road dust suppression, wash-down and construction demands.
3. Apirnta Facility dust suppression and construction demand.

A borefield would be sited to the north-east of the decline entrance and would target the Langra groundwater system at a depth of approximately 150 metres below ground level. Bores would be spaced at a distance of approximately 200 metres and connected to electro-submersible pumps. Abstracted water would be gravity fed to a water storage retention dam as shown in Figure 3-1..

A series of production bores would be sited at approximately 8 kilometres intervals along the Chandler Haul Road, with two additional production bores, one at each end of the Chandler Haul Road. Based on site investigation works undertaken to date and the results of the site conceptual model (refer to Section 8.4), bore depths would target the Langra Formation.

Bores would be operated on a throttled float system to pump groundwater to above-ground storage tanks when the water level in the storage tanks drops below 50 % capacity. Water carts would connect to the storage tanks as required along the Chandler Haul Road.

Potable water supply

To meet the accommodation village and drinking water demand, two large diameter production bores (approximately 250 millimetres in diameter) would be constructed.

Extracted groundwater would be piped to a site water treatment plant. Water would then be treated to Australian Drinking Water Guidelines (NHMRC 2011). The system would likely comprise the following treatment processes:

- Staged microfiltration.
- Reverse osmosis (or dilution).
- Carbon filtration.
- Chlorination.
- Water softening.
- Ultra violet disinfection.

Treated water would then be stored in two enclosed steel tanks with a combined capacity of 40,000 L. Following use, grey water would be reticulated back through the water treatment plant. The proponent has set a 50 % recycled water target.

The construction water demands for the Proposal are summarised in Table 8-4.

Table 8-4 Construction phase water demands

Demand	Water type	Average volume (ML/year)	Source
Dust suppression			
Overburden/ ore removal	Saline	43	Various lithologies
Chandler haul road and Henbury access road	Saline		Horseshoe Bend Shale / Langra Formation / Stairway Sandstone Formation
Internal roads	Saline		Horseshoe Bend Shale / Langra Formation
Process water			
Other process demand	Saline	9	Langra Formation
Washdown bays	Non-saline	2	Horseshoe Bend Shale / Langra Formation
Workforce consumption			
Personnel – potable	Potable	16	Horseshoe Bend Shale / Langra Formation
Personnel – ablutions and non-potable	Non-saline	Reticulated	Horseshoe Bend Shale / Langra Formation
Saline demand		54	
Potable demand		14	
TOTAL CONSTRUCTION DEMAND		70	

Notes: 1.ML/year=mega litres per year.

Chandler Facility and accommodation village

Two production bores would be located adjacent to the decline portal within the mine infrastructure area of the Chandler Facility. They would target the Langra groundwater system (140 to 220 metres below ground level). Water supply would be used for construction ahead of mining. The potential impact of drawdown associated with this activity have been modelled. The results discussed in Section 8.4.3 indicate there is a low risk of drawdown (0.2 metres within a one kilometre).

Chandler Haul Road, Henbury Access Road and Apirnta Facility

Four production bores sited along the Chandler Haul Road would target the Langra and Stairway Sandstone groundwater systems at depths of between 50 and 150 metres below ground level and would meet dust suppression and construction water demands along the Chandler Haul Road and at the Apirnta Facility.

Impacts are minor, with only minor localised drawdown predicted as a result of extraction from these bores (i.e. 0.2 metres drawdown within 1 kilometre, based on the de Glee analytical model calculation; refer to Section 8.4.3). Landholder bores (RN10082 and RN14584) abstracting water from the Stairway Sandstone groundwater system are both located greater than 300 metres from the Chandler Haul Road and are not considered to be adversely impacted by abstraction demands.

Discussion of drawdown impacts

A pumping test undertaken at the existing production bore (PB1) at a sustained abstraction rate of 4 L/s resulted in negligible drawdown within the Langra groundwater system, with nearby observation bores (WT1 and WT2) not influenced by dynamic head changes in the piezometric

surface. This is consistent with the site conceptual model and the de Glee analytical model calculations of Section 8.4.3.

The proposed abstraction rate (approximately 2 L/s) required for construction and operation water demands is considered to result in very minor changes to the local piezometric surface (i.e. 0.2 metres drawdown within 1 kilometre). A similar dynamic response in groundwater levels is expected within the Stairway Sandstone along the Chandler Haul Road, with abstraction demands for dust suppression likely to result in minor localised drawdown.

As discussed in Section 8.4.3., potential for drawdown impacts arising from the Proposal would be of such low magnitude and localised extent that they would not reach the spring areas listed in Table 8- 5.

Elsewhere, the relatively minor drawdown associated with Proposal-related abstraction is of such a low magnitude and localised extent that is unlikely to cause any impacts of concern to those sensitive receivers listed in Table 8-5 is not explored further as a potential impact.

Contamination of borefield aquifer from site activities

Site activities have the potential to contaminate the groundwater resource through actions such as spills, equipment failure or accidents. For groundwater bores, this would relate to drilling activities. If a potential contamination incident were to occur, appropriate emergency actions would be undertaken (refer to Section 8.8).

Measure that would be taken to avoid direct impacts on groundwater resources during drilling are detailed in Section 8.8.

Summary of direct impacts

Potential direct impacts of groundwater abstraction on local water users, receiving environments and groundwater quality during construction are listed in Table 8-5, noting the drawdown modelling results in section 8.4.3 (0.2 metres drawdown within 1 kilometre, based on the de Glee analytical model calculation).

Table 8-5 Key sensitive receptors and their water source

Receptor	Water source	Potential impacts
Groundwater supplies		
Rocky Hill borefield	Mereenie Aquifer System	• Contamination of drinking water supply due to derailment of train carrying hazardous wastes. • Groundwater drawdown.
Roe Creek borefield	Mereenie Aquifer System	• Contamination of drinking water supply due to derailment of train carrying hazardous wastes. • Groundwater drawdown.
Titjikala water supply	Titjikala bore	• Contamination of drinking water supply due to truck overturning carrying hazardous wastes. • Contamination arising from hazardous waste storage. • Groundwater drawdown.
Idracowra stock water supply	Alluvium	• Contamination arising from hazardous waste storage. • Groundwater drawdown
Springs		
Pascoes spring	Amadeus Basin	• Reduced groundwater flows due to construction and operation dewatering impacts. • Contamination arising from hazardous waste storage leakage.
Horseshoe Bend spring		
Polly's spring		
Black Hill spring		
Mick's spring		
Riparian vegetation		
River Red Gum woodland (Eucalyptus camaldulensis var. obtusa)	Alluvium – combination of interflow and perched groundwater	• Contamination of alluvial groundwater systems via infiltration of mine surface water runoff. • Dewatering of shallow groundwater systems.
Coolabah woodland (Eucalyptus coolabah subsp. arida)		

8.5.2 Indirect impacts

Construction may indirectly impact vegetation within the vicinity of the proposed development footprint that may be partially dependent on groundwater.

Groundwater dependent ecosystems

There are no known groundwater dependant ecosystems within the vicinity of the Proposal. There is the potential for low to moderate impacts to River Red Gum and Coolabah vegetation proximal to the Proposal area, as these ecosystems are considered to be partially dependent on groundwater.

As discussed in Section 8.3, two ecological communities (*Eucalyptus camaldulensis* var. *Obtuse* and *Eucalyptus coolabah* subsp. *Arida*) have been identified by DENR to persist within the riparian corridors of the Finke and Hugh Rivers. The root structure is considered to be shallow (less than 15 metres) and dependent on the perched shallow groundwater systems (i.e. near-surface alluvial sources) associated with ephemeral creeks, rather than the water table at about 80 metres depth.

The Proposal is unlikely to impact storage within the alluvium, with mining and groundwater abstraction targeting the deeper (220 plus metre area) hard rock groundwater systems. The surface water assessment presents information on any surface water related impacts.

8.6 Assessment of risks during operation

This section presents the potential impacts (both direct and indirect) on groundwater during operation of the Proposal. Mitigation measures to avoid or reduce these impacts are discussed in Section 8.8.

8.6.1 Direct impacts

Direct impacts on groundwater during operation may include groundwater abstraction resulting in drawdown and impacts to private landholder bores. These impacts are discussed below.

Groundwater abstraction would service potable and raw water supply demands during operation of the Proposal (refer to Table 8-6). A maximum groundwater demand of approximately 113 mega litres per year would be required during operation of the Proposal. Abstraction would service the following primary activities and by doing so, may give rise to impacts on local groundwater resources:

- Raw water supply
    - Chandler Facility and accommodation village.
    - Hydraulic backfill processing.
    - Chandler Haul Road.
    - Apirnta Facility.
    - Henbury Access Road.
- Potable water supply.

Raw water supply

During operation, raw water would be abstracted to service three key activities:

1. Mining operations.
2. Chandler Facility dust suppression, drilling and construction demands.
3. Chandler Haul Road/Apirnta Facility dust suppression, wash-down and construction demands.

Potable water supply

There would be no change between construction and operation water supply. Raw water during operations would still need to meet the requirements of the accommodation village and drinking water demand. It is anticipated that two large diameter production bores (approximately 250 mm diameter) would be constructed.

Extracted groundwater would be piped to a site water treatment plant. Water would then be treated to Australian Drinking Water Guidelines (NHMRC 2011).

Table 8-6 Operation raw water demands

Demand	Water type	Average volume (ML/year)	Source
Dust suppression			
Overburden/ ore removal	Saline	43	Various lithologies
Chandler haul road and Henbury access road	Saline		Horseshoe Bend Shale / Langra Formation / Stairway Sandstone Formation
Internal roads	Saline		Horseshoe Bend Shale / Langra Formation
Process water			
Process water (hydraulic backfill)	Saline	45	Re-use from hydraulic backfill process and Langra Formation
Other process demand	Saline	9	Langra Formation
Washdown bays	Non-saline	2	Horseshoe Bend Shale / Langra Formation
Workforce consumption			
Personnel – potable	Potable	14	Horseshoe Bend Shale / Langra Formation
Personnel – ablutions and non-potable	Non-saline	Reticulated	Horseshoe Bend Shale / Langra Formation
Saline demand		**99**	
Potable demand		**14**	
TOTAL OPERATION DEMAND		**113**	

Mining

The Proposal would intercept groundwater during the construction of the mine decline and the two ventilation shafts. Three localised groundwater systems are expected to be intercepted during the construction phase of the Proposal. These are understood to be:

- The Horseshoe Bend Shale Formation.
- The Langra (Upper and Lower) Formation.
- The Stairway Sandstone Formation.

Subject to further drilling within the mine infrastructure area, a fourth localised system may be encountered, namely the Jay Creek Limestone Formation.

The limited extent of these fractured rock groundwater systems as identified by the extensive surface and downhole geophysical surveys and detailed in the site conceptual model, is likely to result in limited groundwater storage.

This is further evidenced by the pumping test at the existing production bore (PB2), where transmissivity and sustainable yield both indicated the Langra groundwater system was only capable of supporting small groundwater yields. Therefore, any groundwater inflows to the decline and

ventilation shafts are expected to be easily managed using standard underground mine sealing techniques during construction and operation of the Proposal.

Any groundwater intercepted during construction is likely to result in the dewatering of the localised groundwater systems. Due to the limited extent of these systems and the stratified nature of the geology, dewatering impacts arising from mining operations are not expected to impact those sensitive receivers identified in Table 8-5.

The proponent would construct multiple engineering barriers to prevent groundwater inflow during the construction of subsurface works to limit the extent of dewatering. Details of mitigation/control measures, notably including shot-creting of any significant inflow areas along the decline and/or mine path, are provided in Section 8.7.1.

Impacts to private landholder bores

Registered private landholder bore details were obtained from DENR in July 2016. Within a 25 kilometres radius of the Proposal area there are 36 private landholder bores, predominantly utilising groundwater for stock and domestic purposes. Only one bore is used for community and domestic supply i.e. Titjikala bore, located 25 kilometres north-east of the Proposal area.

The majority of the bores are screened in the alluvium and local Titjikala groundwater systems, however deeper bores to the west and east of the proposed Chandler Facility are known to intercept the Stairway Sandstone and Idracowra Sandstone.

As described above and illustrated in Figure 8-17, dewatering impacts arising from the construction of subsurface works are expected to be localised and are not likely to impact the landholder bores identified in this assessment.

Groundwater abstraction within the Stairway Sandstone associated with the operation of the Chandler Haul Road borefield may also result in localised drawdown. Impacts are minor, with only minor localised drawdown predicted as a result of extraction from these bores (i.e. 0.2 metres drawdown within one kilometre of a bore pumping at 2 L/s, based on the de Glee analytical model calculation; refer to Section 8.4.3). Landholder bores (RN10082 and RN14584) abstracting water from the Stairway Sandstone groundwater system are both located greater than 300 m from the Chandler Haul Road and are therefore not considered to be potentially impacted by abstraction demands.

Water resource impacts to the Alice Springs water supply bore fields (Roe Creek borefield and Rocky Hill borefield) arising from Proposal-related dewatering and/or groundwater abstraction is not expected as demonstrated through the conceptual model (refer to Section 8.4).

8.6.2 Indirect impacts

Potential indirect impacts on groundwater resources during operation may include:

- Groundwater dependant ecosystems.
- Groundwater quality
- Hydro-stratigraphy and geo-mechanics (including earthquake risk).

These impacts are discussed below.

Groundwater dependent ecosystems

The Proposal would not target storage or water abstraction within the alluvium zone (up to 40 metres below ground level). Mining and groundwater abstraction would target the deeper groundwater systems (between 140 and 220 metres below ground level). At this depth, the potential for adverse impacts on riparian vegetation or groundwater dependent ecosystems has been assessed as having an unlikely likelihood of occurring with negligible consequence.

Groundwater quality

The Chandler Facility would receive and store hazardous wastes below ground in isolation over the 25-year mining life. The final inventory of waste product to be received is yet to be agreed. An indicative waste inventory to be accepted at the proposed Chandler Facility is provided in Appendix F.

Waste would be transported by rail and temporarily stored above ground within shipping containers at the Apirnta Facility, where it would then be transported by road train and eventually transported down the decline shaft for storage in the Chandler Facility's waste storage repository.

Contamination of groundwater arising from the storage of waste in the underground repository has been quantitatively assessed during operation and post-closure.

The mine's ongoing management of groundwater inflows and surface water flooding at the decline portal is critical to avoid potential contamination. The proponent would implement a multi-barrier approach to the safe storage of wastes over geological time. This would involve a combination of natural (the halite formation) and engineered barriers (decline and shaft seals) to protect the environment and groundwater sources from risks of contamination during construction, operation and post closure.

Contamination of groundwater arising from the storage of waste in the underground repository is unlikely to pose a groundwater contamination risk given the natural impermeability of the Chandler Formation halite resource. In addition, the depth of the proposed Chandler salt mine and deep geological repository in comparison to known groundwater systems provides a vertical separation and barrier of about 400 metres. This comprises low permeability overburden material between the waste repository and the nearest overlying groundwater system.

During construction and operation, it is anticipated that geophysical surveying would be used to identify faults/features of interest up to several hundred metres ahead of and prior to excavation

with the mine layout subsequently adjusted to avoid such structures. The Proposal is not expected to be intersected by any geological faults or features that could be a pre-existing pathway to the overlying formations or groundwater resources.

Hydro-stratigraphy and geo-mechanical risks

The mining process would result in localised alteration to the physical structure and distribution (i.e. stratigraphy) of the Horseshoe Bend Shale, Langra, Stairway Sandstone, Jay Creek Limestone, Giles Creek Dolostone and Chandler Formations.

On a regional scale the current hydro-stratigraphy and associated aquifer properties are not expected to change.

Due to the proposed mining method (room and pillar) and the subsequent commitment to backfilling the mining void with waste material and salt rejects, the potential for subsidence, and alterations to the overlying stratified geology, is not considered a risk. In addition, the proponent has undertaken a detailed geo-mechanical risk assessment of the Chandler Formation and concluded no material risks are likely (refer to Appendix K). A summary of the geo-mechanical assessment is provided below.

Preliminary investigations of the geo-mechanical behaviour of the Proposal were carried out by Douglas Partners (2015) and Atkins (2016). Since relevant data are not available for the Chandler Formation and overlying rocks within the footprint of the facility, the following information was used:

- The geometry of the planned mine layout (i.e. corresponding depth, dimensions and shape of the room and pillar layout).
- Groundwater quality.
- The results of the analyses concerning the non-soluble material of the Chandler Halite (Terra Search 2014).
- Core photographs from the exploratory borehole CH001A (ERCOSPLAN 2014).
- Generic salt mechanics data and results from in situ measurements, derived from previous geo-mechanical studies carried out by Atkins.

Geo-mechanical modelling was undertaken using the finite difference method to analyse the geo- mechanical response of the Chandler Formation and overlying rocks to the excavation and operation of the Proposal over a period of 30 years. The studies employed engineering judgement to analyse the results of the geo-mechanical modelling. Established experience and knowledge enabled the use of appropriate parameters concerning the strength and the constitutive response of the Chandler Formation. The geometry and in-situ geostatic stresses and the boundary conditions that characterise the planned room and pillar mine layout were analysed.

The studies showed that, provided the Chandler Facility is designed and operated appropriately, the excavated cavities would remain stable throughout the operational phase of the facility. In particular, roof spans are required to be sufficiently small to ensure that unacceptable creep convergence of the rooms can be avoided.

A significant influence on the strain that would be undergone by the Chandler Halite is the c. 270 m thick Jay Creek Limestone, which overlies the Chandler Formation. Provided that there are no major

faults or discontinuities within it, the Jay Creek Limestone would act as thick plate that is expected to contribute significantly to the stability of the planned excavations in the halite formation.

At the time of closure, there would be voidage present within the underground geological repository which has been estimated to be in the range 20%-40% (Atkins 2016). This voidage consists of:

- Pore space within solid wastes.
- Pore space between the grains of the salt backfill that surrounds the solid wastes.
- Pore space within the hydraulic backfill rooms.
- Voids between the solid wastes / backfill and the walls of the caverns (because 100 % filling is unattainable).
- Voids between hydraulic backfill and the walls of the caverns (because 100 % filling is unattainable in practice).

Due to the natural properties of salt 'creep', much of this pore space would be reduced, until eventually the waste and backfill provide sufficient support to the salt that creep ceases. It is expected that most of the void space within the wastes and backfill would not be reduced by creep because the waste / backfill material would become grain-supported well before all the voids are lost.

Creep typically occurs in three stages: primary, or Stage I; secondary, or Stage II and tertiary, or Stage III (Figure 8-19).

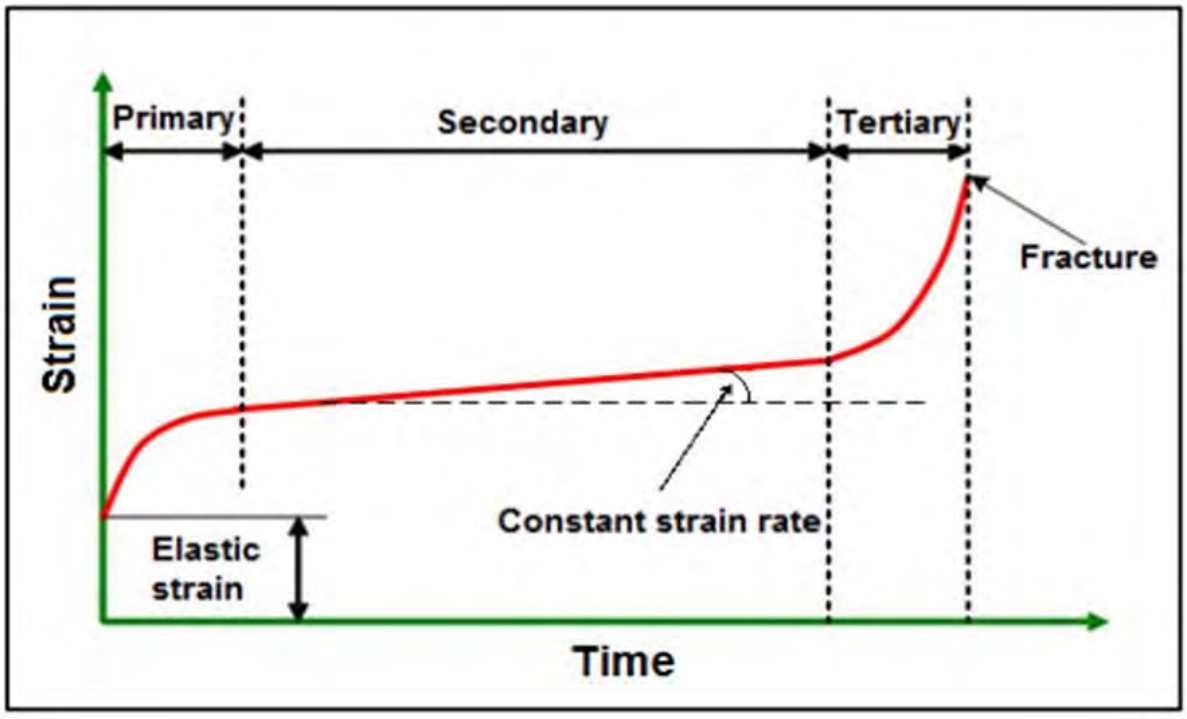


Figure 8-19: The idealised strain-time curve for a creep test - Atkins (2016).

Initially, as load is applied there is virtually instantaneous elastic strain, but over time, under constant stress, the strain rate decreases. With increasing strain, the strain rate continues to



decrease. The time interval over which this decelerating strain-rate occurs is the period of *primary creep*.

The *secondary creep* phase is reached when resistance to creep increases and the strain rate reaches a near-constant, minimum value. This stage is often termed a “steady state creep” period. At the end of Stage II, the strain rate exponentially increases with strain, and the creep rate begins to accelerate, resulting in the initiation of a creep fracture process. This final stage of accelerating deformation that leads to a rapid material failure is called Stage III, or *tertiary creep*.

The rate of convergence of the excavated rooms would be decreased by the presence of waste and/or backfill. Provided the waste is suitably emplaced, backfilling can be done to prevent long-term convergence. The smaller the residual void volume after backfilling, the lower the convergence rate. Rapid waste emplacement and backfilling would allow more control on creep and consequently, there would be accelerated room convergence.

When waste materials that flow are used (hydraulic backfill) they should be emplaced in a manner that minimises unfilled spaces at the level of the roof and improves significantly the support provided by the stored waste. For solid, packaged waste material and the surrounding salt backfill, the initial reduction in the closure rate of the excavated rooms is anticipated to be between 20 % and 25 %. Well-compacted hydraulically backfilled waste materials are expected to result in an initial reduction in the rate of closure between 35 % and 40 %.

Based on geo-mechanical analyses for other facilities (e.g. WIPP; Committee on the Waste Isolation Pilot Plant, National Research Council 1996; USDOE 2014), it is believed that if creep were to persist into Stage III (i.e. brittle failure occurs), the fractures developed would re-seal such that the halite would remain essentially impermeable and therefore, risks to groundwater resources several hundred metres above the Chandler Formation would not be at risk of contamination.

Earthquakes

The Proposal is located in the eastern part of the Amadeus Basin, within a tectonically stable plate interior, thousands of kilometres from the nearest tectonic plate boundaries that are characterised by frequent seismicity and on-going intense deformation (refer to Figure 8-20).

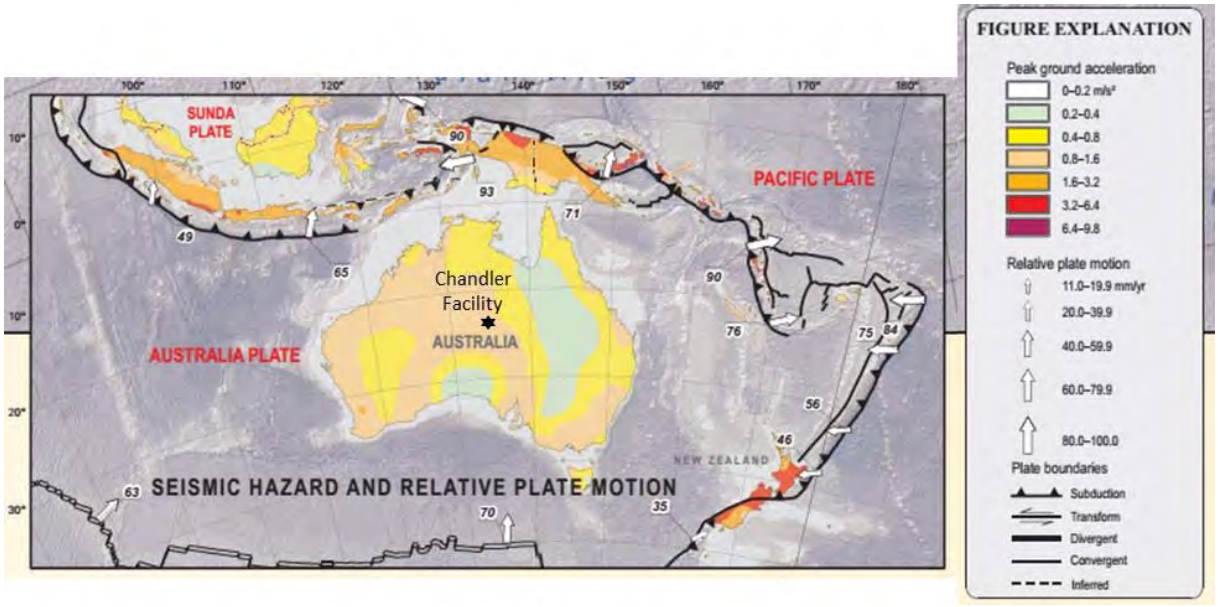
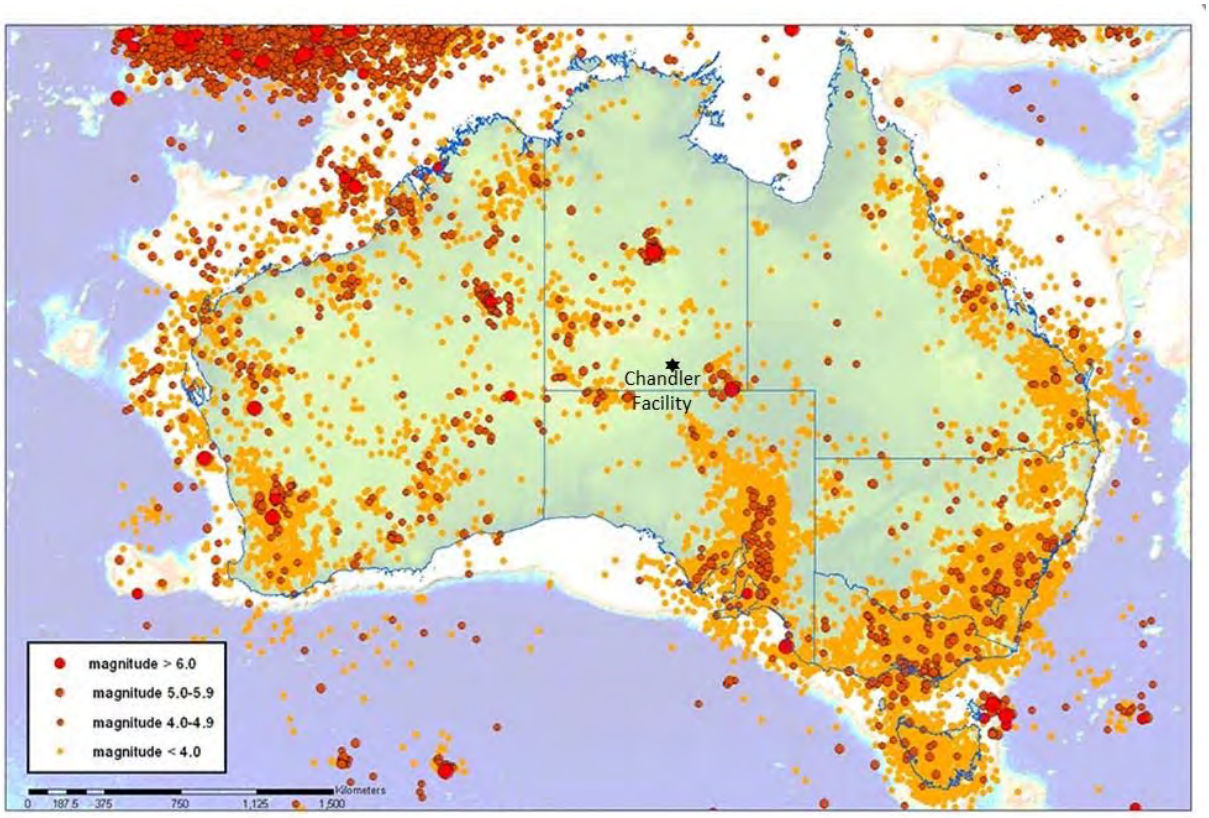


Figure 8-20: Location of the Chandler Facility in the stable interior of the Australian tectonic plate (after Benz et al. 2011).

Nevertheless, earthquakes do occur in stable continental interiors and there have been several earthquakes of magnitude up to 6.6 (the largest recorded in Australia) within the NT (refer to Figure 8-21). However, there have been no recorded large earthquakes within the immediate vicinity of the Proposal.

In the unlikely event earthquakes were to occur, the underground facilities would not be affected significantly, since damaging vibrations occur only at the earth's surface. Extensive research in Japan, a far more seismically active country than Australia, has established the feasibility of siting geological disposal facilities for high level radioactive waste at depths comparable to those proposed for the Chandler Facility (JNC 2000). Seismic vibrations are attenuated rapidly and would be very unlikely to be felt at 850 metres below ground level, the target depth for hazardous waste emplacement (see for example the dataset from Kamaishi Mine, Japan; JNC 2000).



All Australian earthquakes located up to 2011

Source: http://www.ga.gov.au/scientific-topics/hazards/earthquake/basics/where

Figure 8-21 All recorded Australian earthquakes up to 2011. After Geoscience Australia

Earthquakes would only be of concern to the safety of a deep geological facility if the moving fault that causes the earthquake were to intersect the facility. However, under the stress regime in central Australia, new faults are not expected to form. Furthermore, seismic surveys have revealed no faulting within the footprint of the Proposal, or its surroundings (RPS 2013). On this basis, it can be assumed that if any faults do occur, they must be too small to be resolved (displacements likely less than 10 metres).

Since there is a well-established correlation between the sizes (displacements) of existing faults and the magnitude of earthquakes that are likely to occur along them (Wells and Coppersmith 1994), it follows that the risk of movements of existing faults within the Proposal causing significant seismic events is not a concern for the Proposal.

8.7 Assessment of risk during closure and rehabilitation

This section presents the potential impacts (both direct and indirect) on groundwater during closure and rehabilitation of the Proposal. Mitigation measures to avoid or reduce these impacts are discussed in Section 8.8.

8.7.1 Direct impacts

The potential for direct impacts on groundwater during closure and rehabilitation of the Proposal are considered negligible because there would be no requirement to draw on groundwater

resources during this period and all surface facilities would have been decommissioned and rehabilitated.

8.7.2 Indirect impacts

The potential for indirect impacts on groundwater during closure and rehabilitation have been quantitatively assessed by Quintessa and Atkins (refer to Appendix H and K, respectively).

Potential indirect impacts from geo-mechanical failure and earthquakes are discussed above in Section 8.6.2 and conclude no operational (including during backfill) indirect impacts on groundwater resources that lie several hundred metres above the Chandler (Halite) Formation.

The long-term, Post-Closure Risk Assessment, quantitatively assessed risks to the environment, including groundwater, that may arise following closure of the facility. The period covered by quantitative calculations undertaken during the risk assessment is sufficiently long to ensure that maximum risks have been considered (i.e. considering longer periods would not cause greater maximum risks to be estimated at a point in the future). Calculations were undertaken for periods of up to one million years.

The overall approach to the Long-term Post-Closure Risk Assessment followed best international practice[21], in accordance with the requirements of Australian and international regulations, and successful assessments of underground facilities in countries other than Australia, such as hazardous waste and gas storage facilities in the United Kingdom, and radioactive waste disposal facilities in Canada, Finland and Sweden.

In practice the assessment was carried out in a "top-down" fashion, such that the starting point was identifying the main threats to the environment posed by the Proposal during the post-closure phase. The most probable scenario for the future evolution of the Proposal is that the facility behaves as planned and no contamination leaves it following closure (the Expected Evolution Scenario, EES).

To assess the risks of the Proposal unexpectedly not behaving as designed (i.e. the EES not being realised), Alternative Evolution Scenarios (AES) were assessed and included:

- AES1, Connected porosity through the halite roof of the Proposal.
- AES2, Collapsed roof of the Proposal, with the variant:
    - AES2a, Collapsed roof in the Operational Phase.
    - AES2b, Collapsed roof in the Post-Closure Phase.

[21] *Here "best practice" refers to the well-established approaches and methodologies that are widely applied throughout the world for assessing the performance and safety of various kinds of underground waste disposal and storage facilities. These approaches and methodologies have been developed over several decades during many projects, including ones concerned with radioactive waste disposal, CO_2 storage, natural gas storage, and hazardous waste disposal. No single document describes this best practice, but rather the approaches and methodologies are documented in numerous reports by international agencies such as the International Atomic Energy Agency (IAEA), Nuclear Energy Agency (NEA), International Energy Agency (IEA), International Standards Organisation (ISO), national regulators, and project implementers.*

- AES3, Impaired shaft seal.
- AES4, Accidental human intrusion.

The assessment provides confidence that, for the proposed categories of wastes and with appropriate facility design, there would be no significant risks arising from the Proposal in terms of environmental safety or risks to groundwater resources on a local or regional basis during post closure.

8.8 Mitigation and monitoring

8.1.1 Managing groundwater during construction

During construction, the risk assessment identified potential impacts from accidental spills and/or leaks from drilling machinery. These types of impacts could unintentionally contaminate groundwater resources during the construction of mine shafts and the decline. To avoid and minimise these risks, the drilling program would implement shaft sealing techniques as shown in Figure 8-22 and Figure 8-23.

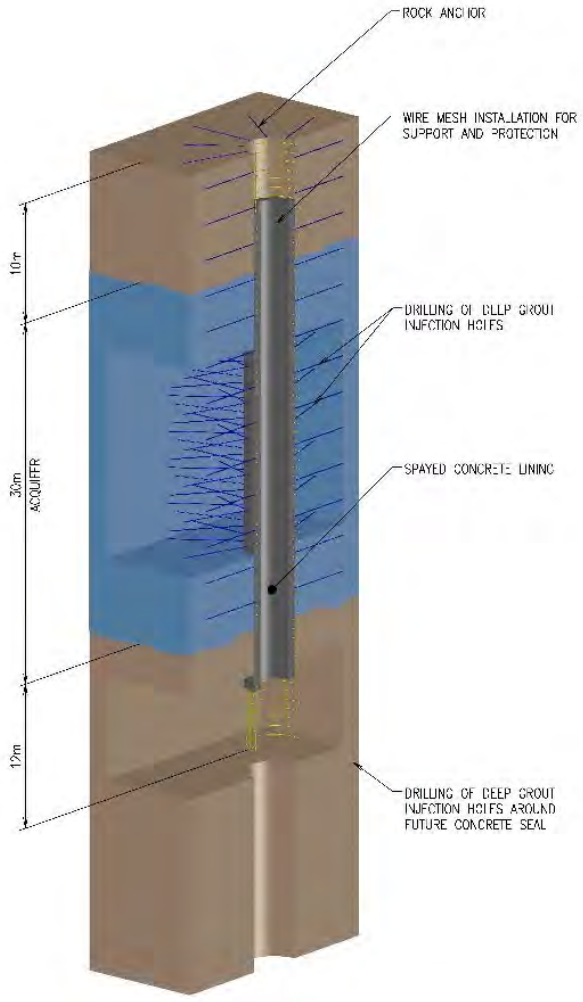


Figure 8-22 Shaft sealing techniques during construction

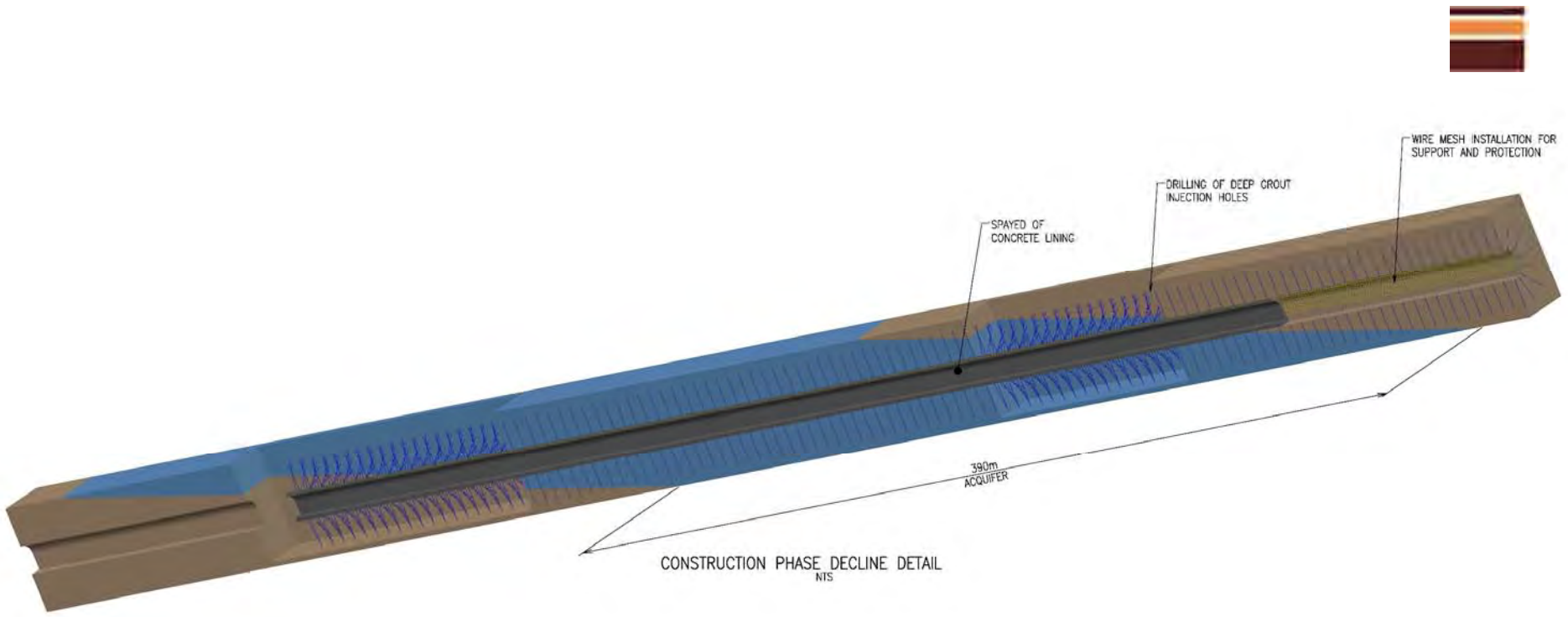


Figure 8-23 Decline sealing techniques during construction

8.1.2 Managing groundwater during operation and post closure

During operation, the risk assessment identified potential impact from leaking shaft /decline seals. These types of impacts could unintentionally contaminate groundwater resources during the operation of the Proposal.

To avoid and minimise these impacts, the drilling program would implement shaft sealing techniques similar to those shown in Figure 8-22 and Figure 8-23. Refer to Table 8-8 for more information on the detail behind the management measures that would be implemented during construction to protect groundwater resources.

8.1.3 Groundwater monitoring

Monthly groundwater level monitoring has been carried out on the existing monitoring network since June 2015 to establish a detailed groundwater baseline. Groundwater quality data has been taken on intermittently during the same period. The established monitoring network would be used for ongoing monitoring during construction and operation to assess groundwater level and water quality trends. Monitoring data would be used to verify predictions during construction and operations based on the preliminary baseline dataset.

Ongoing groundwater quality monitoring would ensure early detection of any change in groundwater quality or possible groundwater contamination.

Ongoing groundwater level and quality monitoring would include:

- Monitoring of targeted groundwater elevations on at least a quarterly basis.
- Targeted groundwater quality sampling on a quarterly basis sampling suite provided in Table 8-7.

Table 8-7 Groundwater quality sampling suite

Analysis / classification	Parameter
In-field analysis	
Depth to groundwater	Metres below top of casing
Chemical properties	pH, dissolved oxygen
Physical properties	Temperature, electrical conductivity, total dissolved solids
Laboratory analysis	
Hydrocarbons	TPH, BTEX, PAH[1]
Dissolved metals	Antimony, arsenic, boron, cadmium, chromium, copper, iron lead, mercury, molybdenum, nickel, selenium, strontium, zinc
Total metals	Antimony, arsenic, boron, cadmium, chromium, copper, iron lead, mercury, molybdenum, nickel, selenium, strontium, zinc
Major ions	Alkalinity, bicarbonate, calcium, carbonate, chloride, hydroxide, magnesium, potassium, sodium, sulfate
Nutrients	Total nitrogen, total phosphorus, nitrite, nitrate, ammonia

Notes: 1. TPH=total petroleum hydrocarbons; BTEX=benzene, toluene, ethylbenzene and xylenes; PAH=polycyclic aromatic hydrocarbons.

The existing and proposed groundwater monitoring program would be revised in consultation with the DENR and NT EPA via the Water Management Plan (Appendix Q).

Additional monitoring locations may be required to monitor drawdown in deeper groundwater systems and drawdown extent during mining at key locations between active groundwater users (including environment) and the mine areas such as:

- Monitoring site(s) in the Langra, Stairway Sandstone and/or Jay Creek Limestone within the Chandler Facility surface infrastructure area.
- Monitoring site(s) between the mine and the Finke River (specifically Horseshoe Bend Spring).
- Monitoring site(s) between the mine and active groundwater users.
- Additional shallow monitoring bore(s) would be installed adjacent to the Apirnta Facility.

Field based physicochemical water quality monitoring of any groundwater dewatered from the mine would occur on a regular basis. Any water dewatered from the mine would be metered to ensure the water management system accurately represents total inflows and outflows across the site.

The draft Water Management Plan contains details for the proposed construction and operation groundwater monitoring program. It would also include the establishment of groundwater level and quality triggers, actions and contingencies that would be implemented in the event that monitoring indicates an adverse impact on groundwater quality.

This process would also comprise the ongoing evaluation of monitoring data and the redefinition of triggers, actions and contingencies if required, in consultation with DENR and NT EPA.

8.1.4 Summary of mitigation and monitoring measures

An overall summary of all proposed groundwater mitigation and monitoring measures are listed in Table 8-8.

Table 8-8 Proposed groundwater mitigation and management measures

ID	Outcome	Mitigation / management measure	Timing
GW.1	Sustainable use of groundwater reserves	Apply for water abstraction licences and permits under the NT *Water Act.*	Pre-construction
GW.2	Avoid groundwater contamination	Grout and seal production bores during construction, operation and post closure (as indicated in Sections 8.1.1 and 8.1.2).	Pre-construction
GW.3	Monitor and record groundwater drawdown	Ensure localised depressurisation of groundwater systems are monitored with data loggers in monitoring bores to ascertain potential of the Proposal to impact local groundwater users. Ensure groundwater level data is reviewed and reported in an Annual Environmental Monitoring Report (AEMR).	Pre-construction, construction, operations, post-closure
GW.4	Develop of detailed groundwater quality database	Report groundwater quality results to the DPIR and the NT EPA every four months (April, August and December) to compare seasonal data against project activities.	Seasonal (on a rolling basis over the life of the mine).
GW.5	Consultation to develop a local groundwater database	Undertake a hydro-census (condition) survey of local groundwater users prior to construction to ascertain bore condition and current status of the bores located within a 25 kilometre spatial buffer around the proposed Chandler Facility. Involve consultation with local groundwater users, with an end purpose of establishing baseline conditions of existing local groundwater users.	Pre-construction
GW.6	Develop a detailed groundwater database	Construct four additional water monitoring sites (as nested sites) to observe shallow groundwater and to monitor deeper systems predicted to be intercepted through mining activities. Monitor groundwater levels and quality near Titjikala, the Finke River, and within the deeper groundwater systems (Stairway Sandstone and Jay Creek Formations) near the proposed mine portal. Undertake shallow monitoring of ephemeral groundwater in aeolian/alluvial sediments at the Chandler Facility and Apirnta Facility to monitor any pollutant losses into the sub-surface.	Pre-construction
GW.7	Develop a detailed groundwater database	Complete a groundwater isotope study for monitoring bores prior to construction to confirm the relationship between shallow and deeper groundwater systems, and to confirm the origin and residence time of groundwater.	Pre-construction
GW.8	Develop a detailed groundwater database	Despite there being no known groundwater dependent ecosystems in the immediate vicinity of the Proposal, potential groundwater dependent ecosystems should be monitored and modelled through detailed design if identified to be potentially impacted by the Proposal. Establish a monitoring program if potential groundwater dependent ecosystems are identified to be impacted through the construction, operation or closure and rehabilitation of the Proposal.	Pre-construction (detailed design)
GW.9	Avoid groundwater contamination	Ensure that the management of groundwater and surface water inflow into the mine portal and ventilation shafts, including the design and capture of this water is undertaken in consultation with the DPIR who administer the Mine Management Plan.	Construction
GW.10	Sustainable use of groundwater reserves	Ensure preference is given to re-use groundwater inflows over potable water for construction activities, where reasonable and feasible.	Construction
GW.11	Develop a more detailed understanding of local groundwater network	Refine or further develop the groundwater model to verify the predictions within the EIS (if water level variations outside of the natural range are observed). Ensure modelling is consistent with established guidelines, which allow for analytical or numerical modelling if appropriate for the project context and risks, subject to discussion and agreement with government agencies.	Operations
GW.12	Develop a detailed groundwater database	Monitor groundwater abstraction in production bores. Fit a cumulative flow meter to each production bore, and install pressure transducers in each bore to monitor groundwater drawdown at source.	Construction, operations, post-closure

8.9 Summary of risk assessment

A summary of the risk assessment undertaken for groundwater during construction, operation, closure and rehabilitation of the Proposal is provided in Table 8-9.

Table 8-9 Summary of groundwater risk assessment

Hazard	Pre-mitigated risk			Post-mitigated risks			Risk outcome
	Likelihood	Consequence	Risk ranking	Likelihood	Consequence	Risk ranking	
Changes to groundwater levels	Almost certain	Minor	High	Possible	Minor	Medium	Risk reduced
Changes to groundwater chemistry	Possible	Minor	Medium	Remote	Minor	Low	Risk reduced
Changes to groundwater flow (direction)	Possible	Moderate	Medium	Remote	Minor	Low	Risk reduced
Contamination of Horseshoe Bend Shale aquatards from drilling activities	Remote	Major	Medium	Eliminated	Major	Eliminated	Risk reduced
Contamination of Langra aquifer from drilling activities	Remote	Major	Medium	Eliminated	Major	Eliminated	Risk reduced
Contamination of Hermannsberg Formation groundwater from drilling activities	Remote	Major	Medium	Eliminated	Major	Eliminated	Risk reduced
Contamination of Stairway Sandstone groundwater from drilling activities	Remote	Minor	Low	Eliminated	Minor	Eliminated	Risk reduced
Contamination of Jay Creek Limestone groundwater from drilling activities	Remote	Minor	Low	Eliminated	Minor	Eliminated	Risk reduced
Contamination of Titjikala water supply through loss of containment	Eliminated	Catastrophic	Eliminated	Eliminated	Catastrophic	Eliminated	Risk same
Contamination of Alice Springs aquifer through loss of containment	Eliminated	Catastrophic	Eliminated	Eliminated	Catastrophic	Eliminated	Risk same
Contamination of Great Artesian Basin through loss of containment	Eliminated	Major	Eliminated	Eliminated	Major	Eliminated	Risk same

Contamination of livestock through loss of containment	Eliminated	Major	Eliminated	Eliminated	Major	Eliminated	Risk same
Uncontrolled inflow of groundwater during construction	Unlikely	Minor	Low	Remote	Minor	Low	Risk reduced
Uncontrolled inflow of groundwater during operations	Remote	Catastrophic	Medium	Remote	Major	Medium	Risk reduced
Engineered uses of naturally occurring corrosive groundwater	Almost certain	Major	Extreme	Almost certain	Minor	High	Risk reduced
Over abstraction of groundwater leading to local or regional drawdown	Remote	Minor	Low	Eliminated	Minor	Eliminated	Risk reduced
Lack of groundwater for supply	Remote	Major	Medium	Eliminated	Minor	Eliminated	Risk reduced

8.10 Conclusion

The Proposal area is within the Chandler Syncline, itself within the south-eastern extent of the Amadeus Basin. The Chandler Syncline hosts various local groundwater systems, all of which have minor confining layers and permeability barriers to groundwater flow.

The depth to groundwater at Chandler is about 90 metres, and the groundwater is saline. The basal unit overlying the Chandler Formation and target salt resource is the Giles Creek Dolostone Formation, comprising predominantly of marine shale, silt and sand sediments and thin beds of dolomite at a depth of about 830 metres. The Giles Creek Dolostone does not host groundwater.

Overlying the Giles Creek Dolostone is the Jay Creek Limestone Formation, a 170 metres thick geological unit comprising predominantly shale, silt and sand. Overlying the Jay Creek Limestone Formation is the Stairway Sandstone Formation, a thick sequence comprising predominantly continental coarse to medium grained sandstone within interbedded minor silt and shale beds. The Stairway Sandstone supports numerous landholder bores within the region at shallower depth (<100 metres BGL).

Overlying the Stairway Sandstone Formation is the Langra Formation, subdivided into three member units, represented at depth by interbedded silt and shale beds, gradually transitioning into extensive fine to medium grained sand. Overlying the Langra Formation is the Horseshoe Bend Shale Formation, a massive siltstone and quartzitic sandstone deposit. Both the Langra and Horseshoe Bend Shale Formations host brackish to saline groundwater.

The inferred piezometric surface ranges between 60 and 90 metres BGL across the Chandler Facility. Directly above the Horseshoe Bend Shale Formation and partially eroded at surface across the Proposal area is the Idracowra Sandstone, a kaolinitic sandstone represented across the Maryvale Hills and discontinuous across the Proposal area. The Idracowra Sandstone supports numerous groundwater users within a 25 kilometre radius of the mine. Groundwater is typically saline and as such is used locally as a stock supply. The Idracowra Sandstone Formation will not be intercepted by mining.

Locally in the vicinity of the Proposal area, there is very low recharge from direct rainfall, but minor recharge is expected to occur via infiltration from overlying alluvial systems during major flooding events.

Minor direct rainfall recharge may occur locally, but the low rainfall and high evaporation means this volume would be minimal and the presence of stratified low permeability clays and silts in the middle and lower members of the Langra Formation is likely to result in the formation of perched localised groundwater systems in the upper Langra Formation and Horseshoe Bend Shale Formation. The underlying Stairway Sandstone Formation and Jay Creek Limestone Formation are likely to receive negligible recharge where the two geological units outcrop at surface along the Charlotte Ranges to the west of the Chandler Facility due to their limited outcrop extent and distant location from ephemeral creek lines.

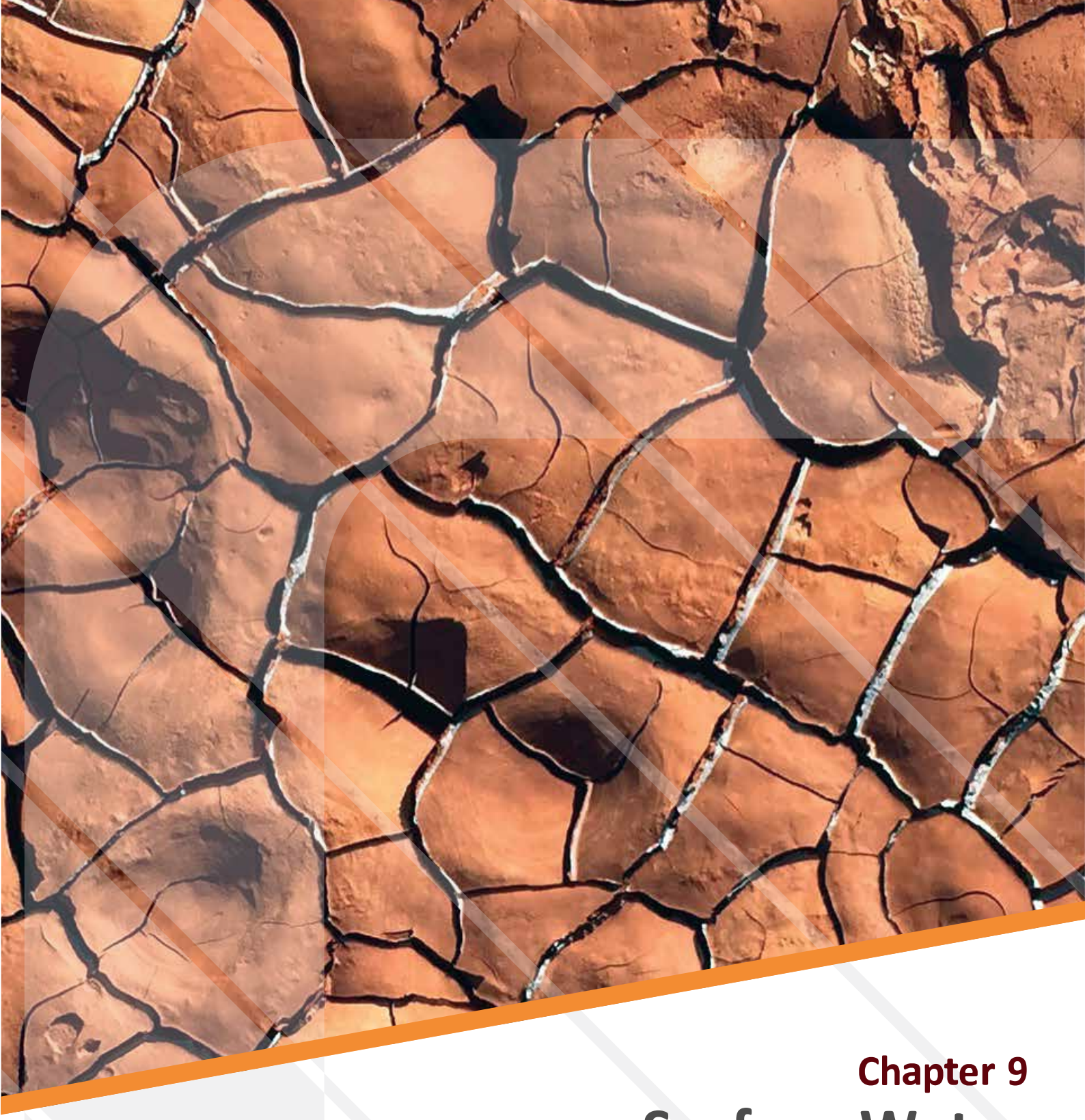
Consistent with topographic gradients, hydraulic gradients are very gentle in the south-eastern extent of the Amadeus Basin, and the broad flow direction in all groundwater systems is generally from north-west to south-east, however, the basement structure influences the groundwater flow direction in certain areas. The structural influences are typically associated with folding.

The horizontal hydraulic conductivity in geological units is highly variable, due to the depositional environments and volume of clay; groundwater flow through Formations is therefore not expected.

There is an upwards hydraulic gradient from the Langra Formation to the Horseshoe Bend Shale Formation based on pressure head differences observed through groundwater monitoring. Elsewhere, within the 25 kilometre spatial buffer around the Chandler Facility, landholder bores located within the shallow alluvium associated with ephemeral creeks report shallow groundwater levels which are likely to be perched systems, with low rates of vertical leakage to the underlying Idracowra Sandstone Formation and Horseshoe Bend Shale Formation.

The saline groundwater quality within the Chandler Syncline differs markedly from the potable water quality reported for the Mereenie Aquifer System about 100 kilometre north within the Northern Amadeus Basin (the MAS is utilised for the Alice Springs Water Supply). The Chandler Syncline is a separate groundwater system entirely, given that the MAS units occur within the Northern Amadeus sub-basin and Orange Creek Syncline, but do not occur within the Chandler Syncline. The evidence confirms that the Chandler Syncline is distinct and separate from the Mereenie Aquifer System in terms of geological structure, lithological units, groundwater flow properties, hydraulic gradients and water chemistry.

Water quality within shallow alluvial groundwater accessed by landholder bores to the north and west of the Chandler Facility, particularly at Titjikala can be characterised as potable. Whereas groundwater quality observed within the Horseshoe Bend Shale and Langra local groundwater systems are poor and equivalent to seawater. Salts originating from the marine depositional environment, and the enhanced climatic nature of the environment (i.e. low precipitation/high evaporation), coupled with long groundwater residence times is likely to contribute to the poor groundwater quality observed within the Chandler Syncline.



Chapter 9
Surface Water



This page has been left intentionally blank

9 SURFACE WATER

9.1 Introduction

An environmental impact statement (EIS) has been prepared to address specific requirements provided in the *Final Guidelines for the Preparation of an Environmental Impact Statement* for the Proposal application, issued on 23 September 2016.

This assessment has been prepared as part of the EIS to address the specific surface water requirements in the environmental assessment guidelines. Specifically, the assessment addresses the key requirements of the NT EPA and other NT Government agencies with jurisdiction over surface management.

The relevant requirements in the Final ToR relating to water are listed in Appendix A and include the section of this report and supporting documentation in Appendix N where they are addressed. The information presented in this Chapter summarises the main findings of specialist surface water investigations and reports to support the EIS (see Appendix R).

The objectives of this assessment are to:

- Identify and assess potential impacts on surface water from the development of the Proposal;
- Satisfy the Final ToR and other relevant agency requirements relevant to surface water impact assessment.
- Inform the wider community about the Proposal and its potential impacts on the local and regional water environments.

To achieve these objectives, the water assessment:

- Assesses the existing hydrological environment using a risk based approach, and baseline conditions within the Proposal area and its surrounding area.
- Identifies and quantifies the potential risks and impacts of the Proposal on the current surface waters.
- Proposes mitigation and management measures, and monitoring requirements for surface water.
- Discusses relevant legislation with respect to activities involving surface waters.

9.2 Methodology

9.2.1 Literature review

A literature review, drawing on a number of publicly available published reports has been undertaken to conceptualise the regional environment. The review has a particular focus on surface

water environments across the south-east of the NT and the north-west of South Australia. A summary of the critical information sources is included in Appendix R.

9.2.2 Desktop gap analysis

Desktop gap analysis was completed in order to identify drainage channels and surface water features relevant to the Proposal prior to site visit and manipulate data collected during the site visit.

The desktop assessment included the following:

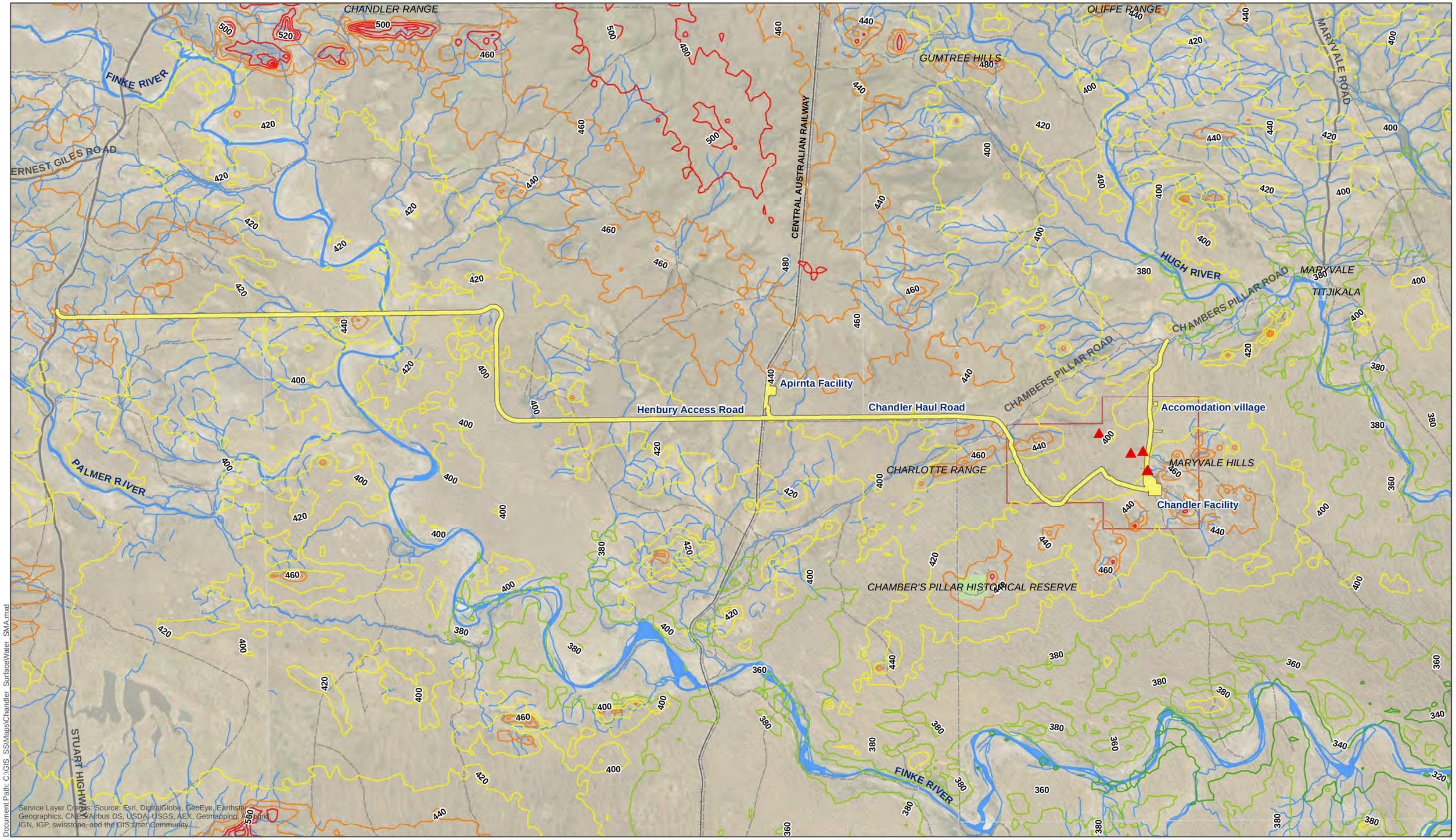
- Review of available literature and data relating to climate / hydrology, geology / soils, geomorphology and vegetation.
- Review of current Proposal baseline monitoring program.
- Review of topographic data to gain an understanding of key watercourse characteristics including bed slope, sinuosity, meander bend characteristics, channel widths / depths.
- Review of recent aerial photography to identify visible features relevant to watercourse geomorphology.
- The findings of the desktop assessment informed the development of a watercourse geomorphology field survey.

9.2.3 Field investigations

Field investigations for the preparation of this EIS were undertaken by the proponent over four years (2013 to 2016). Surface water field investigations continue in 2017 and would do so for the life of the Proposal.

The aim of field investigations was to describe and monitor baseline surface water systems associated with the Proposal. The proponent's existing surface water monitoring locations for the Proposal are shown in Figure 9-1.

Site locations for hydrological, geomorphological and sediment sampling were selected and are shown in Figure 9-2. Sites were located on a representative range of creeks both within and down gradient from the Proposal area and where land permissions could be obtained. Seven sites were selected where existing hydrographic stations were established (i.e. CS005013, CS005021, CS005031, CS005041) or where hydrographic stations are proposed in the near-future (i.e. GEOM01, GEOM2 and GEOM03).



Document Path: C:\GIS_SSt\Maps\Chandler_SurfaceWater_SMA.mxd

N

4 2 0 4 Kilometers

Coordinate System:
GDA 1994 MGA Zone 53

Legend

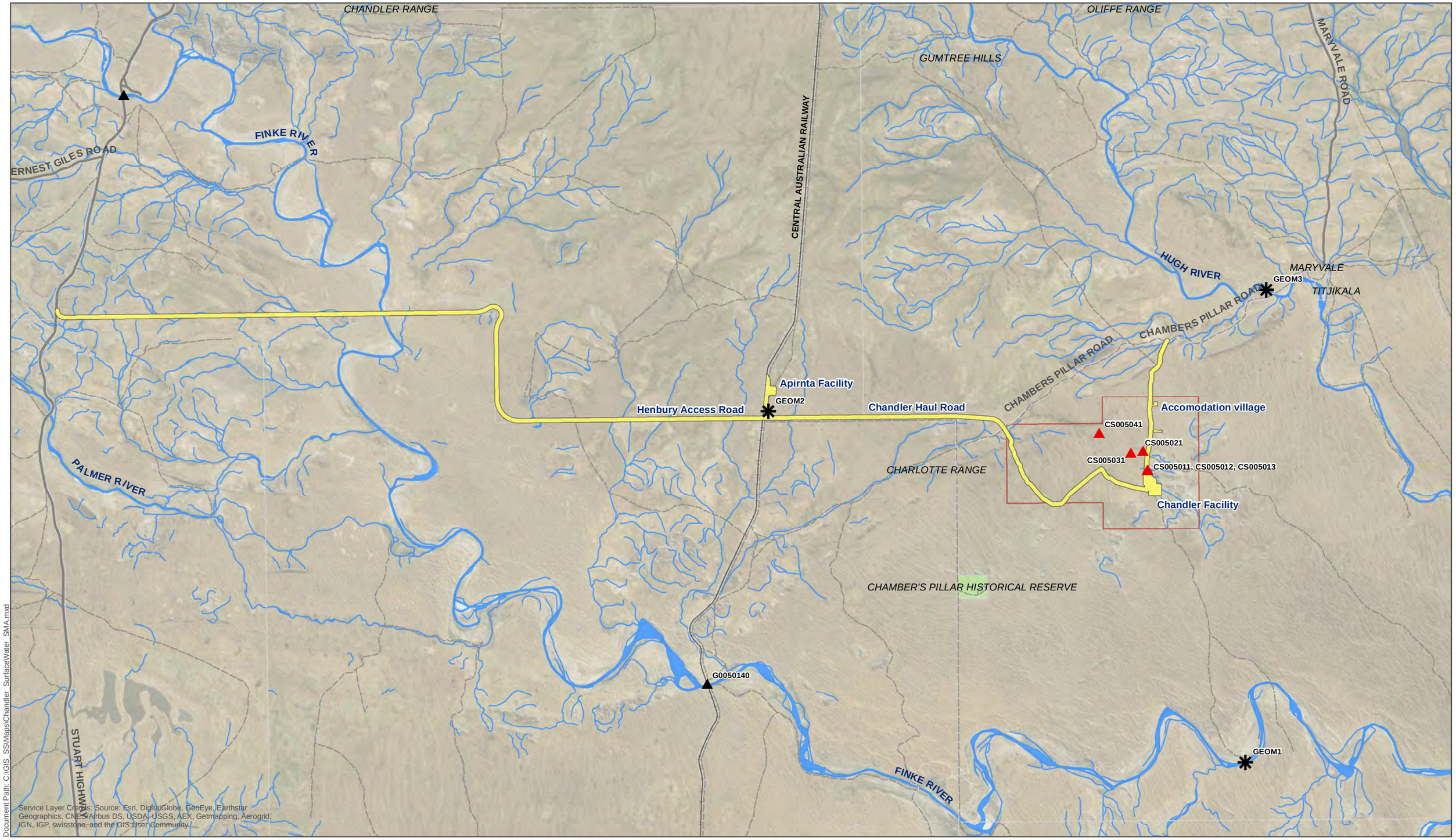
- Proposed development footprint
- Watercourse
- Pastoral boundaries
- Mining Lease Area
- Tellus Holdings hydrostations

Figure 9-1
Existing water monitoring stations

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; USGS, SRTM elevation, 2000; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller



Document Path: C:\GIS_SS\Maps\Chandler_SurfaceWater_SMA.mxd

N

4 2 0 4 Kilometers

Coordinate System:
GDA 1994 MGA Zone 53

Legend

- Proposed development footprint
- Watercourse
- Pastoral boundaries
- Mining Lease Area
- NT Government
- Tellus Holdings hydrostations
- Tellus Geomorphology additional stations

Figure 9-2
Hydrological monitoring stations

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; USGS, SRTM elevation, 2000; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller

Geomorphological conditions rapid walkover survey

A baseline geomorphology review was conducted at all seven sites to provide a snapshot of the current geomorphic conditions and capture the various channel types and characterise the main watercourses within the Proposal boundary. RiverStyles™ classification (Thompson et. al. 2005) was used to describe the main channel types identified in the assessment based on valley setting, channel continuity, river planform, geomorphic units and bed material texture.

Sediment testing

Bed sediment sampling was conducted on 16 and 17 May 2016. Further sediment samples were taken in recent rains but the results were not available at the time of submitting this EIS. Antecedent hydrological conditions immediately prior to the sampling event were wet; 53 mm of precipitation was recorded in the Hugh catchment for the two weeks preceding the site visit (NT Government 2016).

Bed sediment sub-samples were collected at 0, 20, 40, 60, 80 and 100 percentile width increments across the channel using a plastic scoop washed with deionized water to prevent cross-contamination. The six sub-samples were then combined into a composite sample by mixing, double-bagging and sent for the following analysis at a NATA accredited laboratory:

- Electrical conductivity (1:5 soil: water leach).
- Metals suite.
- Moisture content.
- Particle size distribution.
- Total organic carbon.

Quality assurance / quality control analysis was conducted on these samples including blank testing, duplicate testing and spike recovery. No analysis for nutrients or organic compounds (e.g. hydrocarbons, pesticides) was conducted because no significant sources of these chemicals were anticipated within the surface catchments and the Proposal was not expected to affect baseline conditions.

The monitoring of baseline conditions continues during the assessment of this EIS. The proponent is committed to continuing field investigations through the Proposal's detailed design, construction, operation, decommissioning and closure phases. Further data and discussion of baseline data is contained in the BECA report (see Appendix R).

9.2.4 Water quality guidelines

Australian and New Zealand guidelines for fresh and marine water quality

The Australian and New Zealand guidelines for fresh and marine water quality (ANZECC/ARMCANZ 2000) set out the framework for the application of water quality guidelines. These guidelines

describe requirements over a variety of marine and freshwater environments, aquatic ecosystems, primary industries, recreational water, drinking water and monitoring and assessment.

The most appropriate guideline values to compare water quality data against were therefore considered to be national guidelines outlined in ANZECC 2000 Water Quality Guidelines for two conditions:

- The 95 % freshwater aquatic ecosystem protection.
- Primary industries livestock protection.

Adoption of the aquatic ecosystems guideline value was seen as a conservative approach, as the only possible aquatic systems supported in the Study Area were in the semi-permanent waterholes in the Finke River, which in turn has limited hydrological connectivity to the Proposal.

The only sub-catchment linked to the Finke is the Apirnta Creek to the west of the Study Area. As the study area has a small degree of human activity, the study area ecosystem was classified as slightly to moderately disturbed. A 95 % statistically-based protection level is most commonly applied to these ecosystems, and represent the 'no significant adverse effect' guidelines. The objectives of the aquatic ecosystem 95 % protection are to maintain the key ecological processes and diversity as comparable as possible to that of the existing natural habitats within the area.

Chemical and physical indicators (or trigger values) for aquatic ecosystem 95 % protection guidelines are outlined in the BECA report (see Appendix N).

The above guidelines provide an authoritative guide for setting water quality objectives for natural and semi-natural water resources in Australian and New Zealand sustaining current or likely future environmental values (uses). The guidelines were used when assessing the baseline water quality for the Proposal.

NT Government water quality data

NT government has several water quality monitoring stations located within the Study Area. The water quality samples collected at each NT station were compared against the trigger levels for 95 % freshwater aquatic ecosystem protection and primary industries livestock protection (See BECA Report in Appendix R).

The following water features included in this analysis are not within the study area but were included to provide an indication of dam / tank water quality due to limited records within the Proposal area dams:

- Dead Bird Tank.
- Dead Horse Dam.
- Four Winds Tank.
- One Tree Hill Dam.
- River Tank.
- Soakage Dam.
- Top Soak Dam.

Water quality in these dams and tanks is likely to be similar to Charlotte Range Lookout and Robinson Dams. The most appropriate guideline values to compare water quality data against were therefore considered to be national guidelines outlined in ANZECC 2000 Water Quality Guidelines for two conditions:

1. The 95 % freshwater aquatic ecosystem protection;and
2. Primary industries livestockprotection.

Adoption of the aquatic ecosystems guideline value was seen as a conservative approach, as the only possible aquatic systems supported in the study area were in the semi-permanent waterholes in the Finke River, which in turn has limited hydrological connectivity to the Proposal. The only sub-catchment linked to the Finke is the Apirnta Creek to the west of the study area. As the study area has a limited degree of human activity, the study area ecosystem was classified as slightly to moderately disturbed.

A 95 % statistically- based protection level is most commonly applied to these ecosystems, and represent the 'no significant adverse effect' guidelines. The objectives of the aquatic ecosystem 95 % protection are to maintain the key ecological processes and diversity as comparable as possible to that of the existing natural habitats within the area.

Chemical and physical indicators (or trigger values) for aquatic ecosystem 95 % protection guidelines are outlined in Table 9-1.

Table 9-1 Chemical and physical stressor trigger values for aquatic ecosystem 95% protection

Chemical / physical stressor	Trigger value
Aluminium (µg/L)	55
Ammonia (µg/L)	6
Arsenic (µg/L)	24
Boron (µg/L)	370
Cadmium* (µg/L)	0.2
Chromium* (µg/L)	1
Copper* (µg/L)	1.4
EC (µS/cm)	20 -250
Dissolved oxygen (%)	90-120
Manganese (µg/L)	1900
Lead* (µg/L)	3.4
Nickel* (µg/L)	11
Nitrate (µg/L)	700
Mercury (µg/L)	0.6
pH	6.0 – 77.57.5
Phosphate (µg/L)	5
Selenium (µg/L)	11
Silver (µg/L)	0.05
TSS (mg/L)	2-200
Turbidity (NTU)	2-15
Zinc* (µg/L)	8.0

* Site-specific HMTVs were applied to these selected metals based on a hardness correction factor

Good water quality is essential for the livestock production, where contaminates in drinking water can adversely affect animal production. The scope of the guidelines for livestock protection, include biological, chemical and radiological characteristics that may affect animal health. Chemical and physical trigger values for livestock protection are outlined in Table 9-2.

Table 9-2 Chemical and physical stressor trigger values for livestock protection

Chemical / physical stressor	Trigger value
Aluminium (mg/L)	5
Arsenic (mg/L)	0.5
Boron (mg/L)	5
Calcium (mg/L)	1000
Cadmium* (mg/L)	0.01
Cobalt (mg/L)	1
Chromium* (mg/L)	1
Copper* (mg/L)	1
Fluoride (mg/L)	2
Lead* (mg/L)	0.1
Mercury (mg/L)	0.002
Molybdenum (mg/L)	0.12
Nickel* (mg/L)	1
Nitrate (mg/L)	400
Selenium (mg/L)	0.02
Uranium (mg/L)	0.2
Sulfate (mg/L)	1000
TDS (mg/L)	4000-5000
Zinc* (mg/L)	20

* Site-specific HMTVs were applied to these selected metals based on a hardness correction factor

In Table 9-1 and Table 9-2, the bioavailability of cadmium, chromium, copper, lead, nickel and zinc is related to the hardness of the water. If the water found onsite was determined to be hard, hardness modified trigger values (HMTVs) would be developed, as outlined by the ANZECC guidelines, to better represent a site-specific trigger value. The hardness of the water quality data was evaluated against the ANZECC guidelines values outlined in Table 9-3.

Table 9-3 Hardness categories for ANZECC guidelines

Hardness category	Values (mg/l)
Soft	0
Medium	60 to 119
Hard	120 to 400

Water quality naturally changes temporally and spatially in dryland rivers. This makes developing and applying site-specific water quality guidelines and trigger levels very difficult for these rivers (Miles *et al*., 2015). One possible solution is to develop guidelines for both the no-flow and flowing phases. This could be done by collecting and interrogating monitoring data and developing conceptual, probabilistic and/or numerical models that incorporate flow, catchment and in-stream influences.

Such an understanding would assist in guiding the sustainable use and management of watercourses surrounding the Chandler Facility area, Apirnta area and wider study area. This site-specific system would be developed during detailed design and as part of the Water Management Plan once more data has been collected on site.

Desktop studies following site visit

Metal concentrations are generally higher in < 0.063 millimetre fraction than the bulk sediment fraction. Normalisation is a procedure to correct or adjust contaminant concentrations for the influence of the natural variability in sediment composition; in particular for grain size.

In this study, bulk sediment samples have been collected and analysed for metal concentrations and percentage < 63 µm grain size. In this instance, a very simple form of normalisation was suitable whereby bulk sediment concentration data (expressed as mg/kg dry weight) was divided by the percentage '< 63 µm % passing' (expressed as a decimal) (Simpson *et. al.* 2013). Bulk metal concentrations for the current dataset can then be compared on a spatial basis in order to evaluate sediment enrichment, independent of differences in particle size in different creeks.

The ANZECC interim sediment quality guideline values for Aquatic Ecosystem Health (ANZECC 2000) and Queensland guideline reference median range values (DoE 1998) were assessed against both the raw and normalised data. The latter dataset was used in the absence of any NT guidelines (refer to Table 9-4.

Table 9-4 Sediment guideline values to compare to raw and normalised chemical data

Parameter	Sediment guideline values (all mg/kg)			
	ANZECC 2000 ISQG - Low	ANZECC 2000 ISQG - High	Qld RMR - Low	Qld RMR - High
Antimony	2	25	NS	NS
Arsenic	20	70	NS	NS
Cadmium	1.5	10	0.5	1.5
Chromium	80	370	15	240
Copper	65	270	10	64
Lead	50	220	5	20
Mercury	0.15	1	NS	NS
Nickel	21	52	5	40
Silver	1.0	3.7	NS	NS
Uranium	300*	600*	NS	NS
Zinc	200	410	29	130

* Reported in Hardford *et. al.* (2013); NS = No standard

The trigger value that was the lower of the two for each parameter was applied when the ANZECC, Queensland guidelines differed. For antimony, arsenic, silver and mercury only ANZECC guidelines were found.

Proposal water quality guidelines

Existing water quality stations are shown in Figure 9-1. The data collected from these station were compared against the trigger values for 95 % freshwater aquatic ecosystem protection (Table 9-1)

and primary industries livestock protection (Table 9-2). Due to the hardness of the water sample data, hardness modified trigger values (HMTVs) for cadmium, chromium, copper, lead, nickel and zinc were developed as outlined against the ANZECC guidelines. These HMTVs better represent the site-specific bioavailability of these metals in surface water onsite.

Proposal sediment quality data

The Proposal contaminant limits and trigger levels were compared for samples taken at the existing monitoring stations. The results are shown in Table 9-5.

Table 9-5 Comparison of sediment contaminant concentrations to guideline values

Sample code	Chemical concentrations (all mg/kg)										
	Antimony	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Uranium	Zinc
CS005013	<7	<4	<0.4	4	1	2	<0.1	<1	<1	0.1	2
CS005021	<7	<4	<0.4	9	4	3	<0.1	2	<1	0.2	10
CS005041	<7	<4	<0.4	11	4	3	<0.1	2	<1	0.2	9
GEOM02	<7	<4	<0.4	9	3	3	<0.1	2	<1	0.2	5
GEOM03	<7	<4	<0.4	5	2	3	<0.1	2	<1	0.2	7

Key

< = Less than practical quantifiable limit

Below guideline value/s	Equal to guideline values	Exceeding guideline values

9.2.5 Flooding and flood flow hydrographs

Overall approach

The mine site, haul road and railhead lie in the catchments of the Finke and Hugh Rivers. As noted in the Surface Water Baseline Report (Appendix R), flows on both rivers are recorded at the Stuart Highway crossings (as is the Palmer, a tributary of the Finke) and the flows on the Finke are also recorded at the rail crossing.

The Chandler Haul Road crosses the Finke River about 22.8 kilometres east of the Stuart Highway, but west of the railhead. The topographic gradient suggests that water from the mine site would generally drain towards the Hugh River near Titjikala. However, site reconnaissance has shown that hydraulic connectivity between the mine site and the Hugh River is unlikely.

Flood hydrographs have been defined for the catchments draining towards the project infrastructure (mine site, haul road and railhead) using the Australian Rainfall and Runoff (hereafter referred to as

ARR87) guide to flood estimation and HEC-HMS hydrological modelling software. The resulting flood estimates have been verified with reference to the flood frequency of the major rivers. The ARR87 approach requires:

- Catchment areas, lengths and slopes to be defined.
- Design rainfall.
- Storm depth.
- Aereal reduction.
- Profile.
- Lossess.
- Method of the transforming effective rainfall into a flow hydrograph. This includes calculating the Time of Concentration (Tc).

The input parameters for the hydrological modelling are listed in Tables B.1 to B.5 in Appendix B of the Chandler Facility Flood and Hydrology Assessment in Appendix R. The calculated peak flows are in Table B.5 in Appendix B of the same report.

Catchment Delineation

This was done using a 30 metre grid Digital Elevation Model (DEM), catchment delineation shape files from previous studies (though at a larger catchment scale) and aerial photographs. GIS files were produced showing the catchments draining to each low point along the haul road, and for those catchments discharging across the mine site, as shown in Figure 9-3.

The limited DEM information was used to calculate average catchment slopes, which were in the range of 0.2 % to 1.1 %. The location where the watercourse (flow line) crossed the haul road was identified by its distance from the Stuart Highway. For example, the Finke River crossing is at 22.8 kilometres. In the absence of named watercourses, this nomenclature has been retained throughout the report.

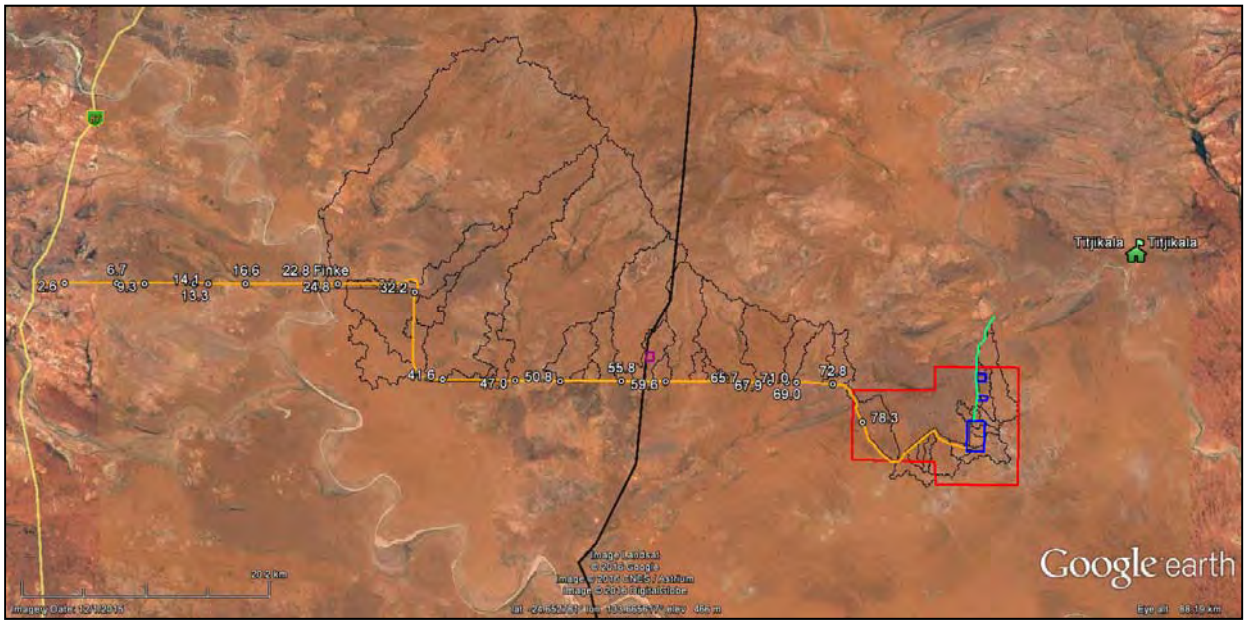


Figure 9-3 Catchment delineation

9.2.6 Design rainfall

Storm depth

Rainfall depths for design storms up to the 100-year Annual Recurrence Interval (ARI) event were taken from a Bureau of Meteorology (BoM) Rainfall Intensity-Frequency-Duration (IFD) table generated for the rail crossing at the Finke River (refer to Figure 2.2 in Appendix R). Values from the same table were used for all catchments relating to the project, as a comparison with IFD tables for the mine site and western end of the haul road (at the Stuart Highway).

Storm profile

The critical storm durations for the catchments were initially defined by the calculation of the catchment time of concentration as being from 1.5 to 24 hours, depending on the catchment size and shape.

Areal Reduction Factor

Design rainfall information for flood estimation is generally made available to designers in the form of point rainfall intensities. However, most flood estimates are required for catchments of significant size and would thus require a design estimate of the areal average rainfall intensity over the catchment.

The ratio between the design values of areal average rainfall and point rainfall, computed for the same duration and annual exceedance probability (AEP), is called the areal reduction factor (ARF). It allows for the fact that larger catchments are less likely than smaller catchments to experience high intensity storms simultaneously over the whole of the catchment area (Engineers Australia, 2013).

Therefore, a factor is applied to the rainfall depth. The factor, which varies according to catchment size and the storm duration, was taken from ARR87 for IFD Zone 5.

Rainfall losses

ARR87 suggests that rainfall losses should be accounted for by applying an Initial Loss (Ia) to the rainfall and then an Ongoing Loss (OL) for the duration of the storm. For 'Central Australia' parts of the Northern Territory, Table 3.8 of ARR87 Book 2 directs the user to the losses for 'Arid Zone' parts of South Australia, which are given in Table 3.4 of ARR87 Book 2. Two combinations of Initial and Ongoing losses are provided; Initial Loss of 15 mm or 40 mm, and Ongoing Loss of 4 mm/h or 1-3 mm/h.

Storm runoff is sensitive to the choice of appropriate rainfall losses. Using an Initial Loss of 40 mm with the BoM IFD rainfall depths would result in no runoff for the majority of design events of 5 years ARI or less.

While selecting a higher Ongoing Loss would result in no effective rainfall from much of the longer-duration storm profiles. Through a combination of professional judgement and verification against storm hydrographs for the Hugh and Finke rivers, the following rainfall losses have been used:

- Initial Loss: 20 millimetres.
- Ongoing Loss: 1 millimetres per hour.

Rainfall flow transformation

The Clark Unit Hydrograph (CUH) method has been used to transform the effective rainfall hyetographs for each catchment into flow hydrographs. The CUH method requires the Time of Concentration (Tc) and CUH Storage Coefficient (Sc) to be calculated using the following equations:

$Tc = 0.76*Area^{0.38}$ where: *Tc = Time of Concentration (hours)*

Area = Catchment area (km^2)

*Sc = Tc *ratio/(1-ration)* *Sc = CUH Storage Coefficient (hours)*

ratio = 0.65 for flat rural catchments

9.2.7 Risk assessment

The assessment of risks on surface water associated with the Proposal was undertaken using the risk assessment approach described in Chapter 6 and Appendix N. The potential risks arising on surface water environments as a result of the Proposal include:

- Soil erosion leading to excess sedimentation in watercourses.
- Vegetation removal.
- Altered hydrology.

- Flooding.
- Contaminated surface water runoff off-site.
- Salt dissolution and transport off-site.
- Contamination of regional surface waters (Hugh and Finke Rivers) through loss of containment.

Discussion of potential impacts associated with these identified risks is discussed in Sections 9.4, 9.5 and 9.6.

9.3 Existing environment

9.3.1 Topography

The topography of the Proposal is characterised by rolling hills and dunes, and sand ridges. However, the general area of the Proposal is bisected by a number of large hills that were created by tectonic activity hundreds of millions of years ago to the north, east and west.

The James Ranges and the Oliffe Ranges, a series of west-east trending ridgelines, rise to 788 metres Australian Height Datum (AHD) and 428 metres AHD respectively to the north of the Proposal area. These ridgelines lie at the southern edge of the Orange Creek Syncline and are predominantly composed of basement rock.

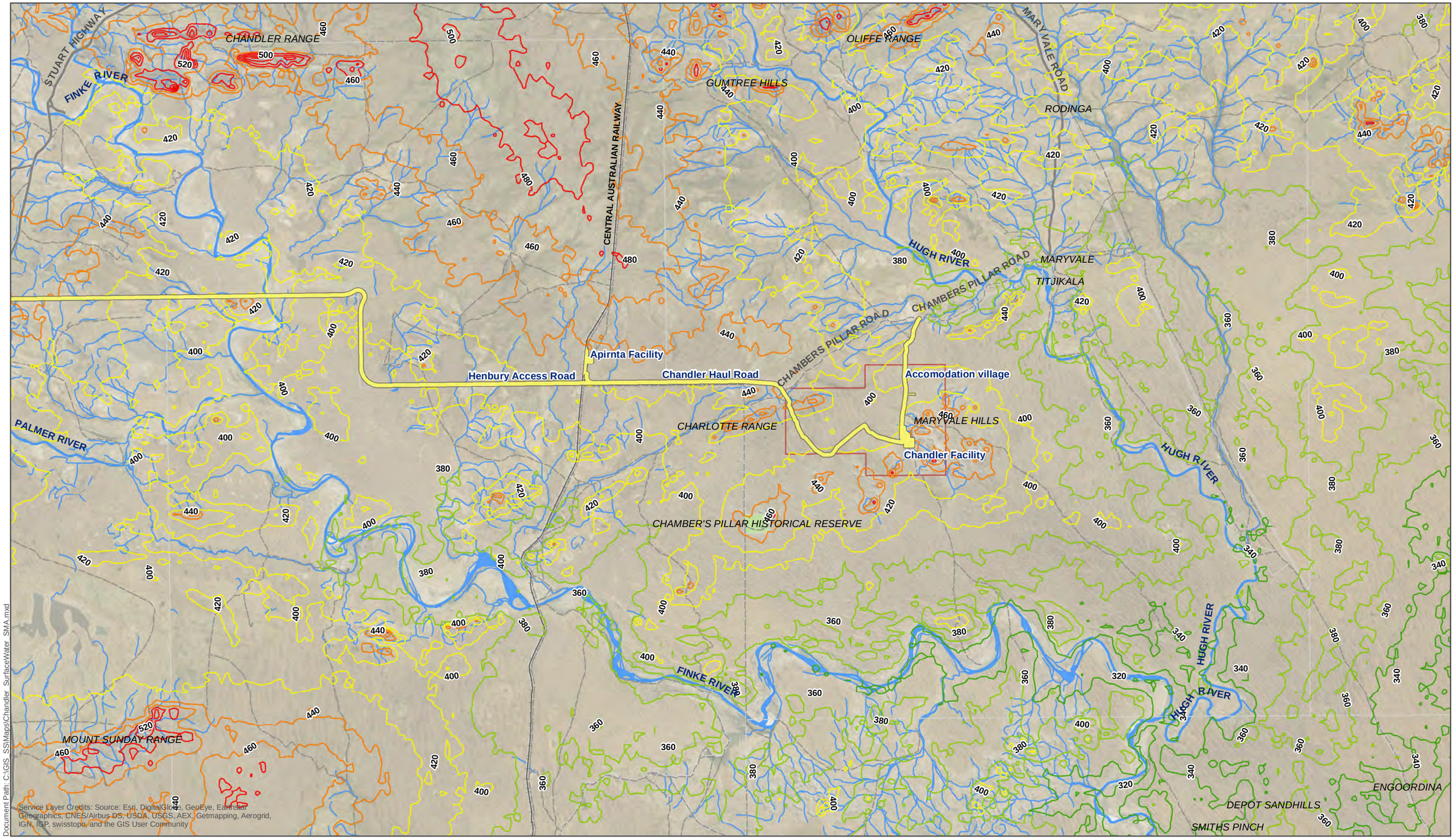
To the east of the Proposal area lies the Rodinga Ranges and the Pillar Range, a series of south-west to north-east trending ridgelines that rise to a maximum height of 350 metres AHD. The Charlotte Range and the Maryvale Hills lie directly west of the proposed Chandler Facility. These topographic highs interrupt the low lying areas dominated by sand dunes and flood plain deposits.

Figure 9-4 shows contours across the study at 20 metre intervals. There is little to no change in elevation at the location of the proposed mine infrastructure area and accommodation village (i.e. 400 metres AHD). The two geological outcrops surrounding the mine infrastructure area, namely Maryvale Hills and Charlotte Range, are both approximately at 440 metres AHD. The area surrounding the proposed Apirnta Facility is approximately 420 metres AHD. Plate 9.1 shows the low

lying floodplain comprising alluvial and aeolian sediment, while the Maryvale Hills and the Charlotte Range may be distinguished in the distance.

Plate 9-1 View south-west toward the Maryvale Hills and Charlotte Range from the proposed Chandler Facility





Document Path: C:\GIS_SSI\Maps\Chandler_SurfaceWater_SMA.mxd

N

4.5 2.25 0 4.5 Kilometers

Coordinate System:
GDA 1994 MGA Zone 53

Legend

- Proposed development footprint
- Watercourse
- Pastoral boundaries
- Mining Lease Area

Figure 9-4
Local topography within the study area

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; USGS, SRTM elevation, 2000; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller

Soil mapping

The Northern Territory Natural Resources Map (NT Government 2015) shows that the study area is dominated by two soil types: Aeolian sands (soil type code Qs) over the flood-out and dune areas and Alluvial Gravel, Sand and Silt (soil type code Qa) along drainage line and creek valleys (Figure 9- 3). A small parcel of Conglomerate Sedimentary soil (soil type code Qc) is present on the northern fringe of the Charlotte Range.

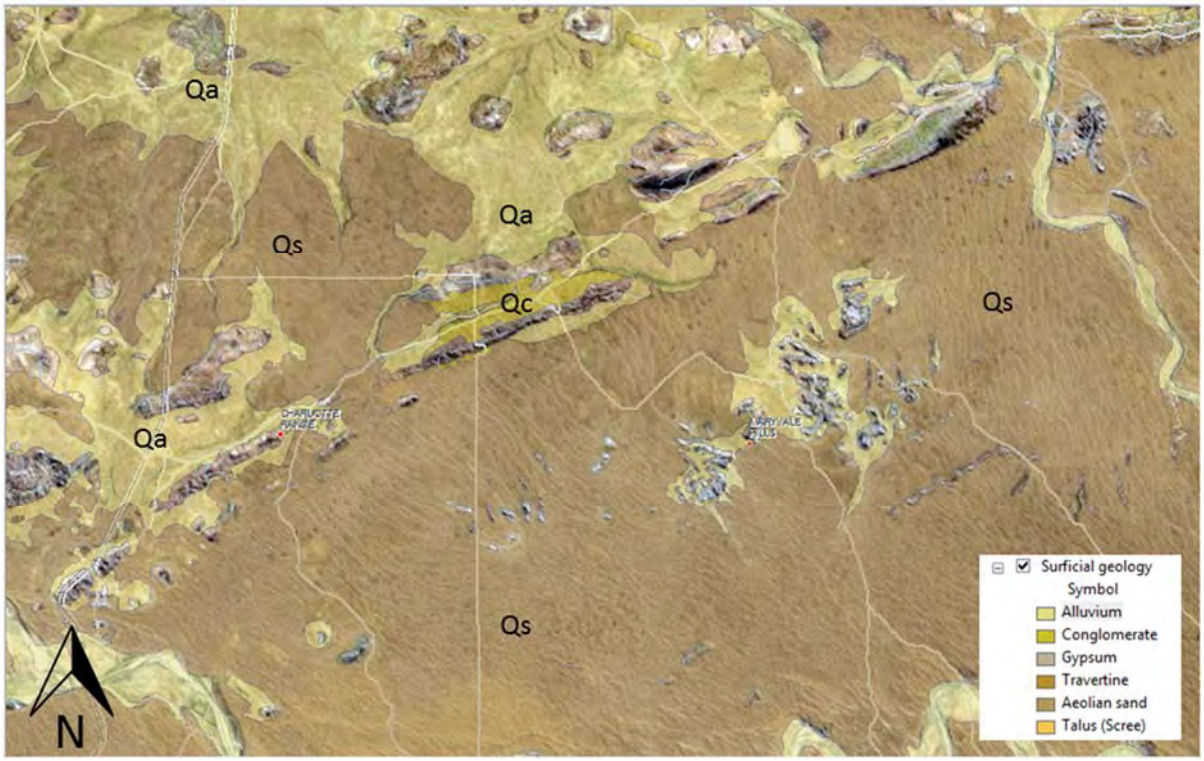


Figure 9-5 Surficial geology in the study area

Soil survey

A soil survey was undertaken in September 2013 (Low Ecological 2013). The spatial extent of the survey was limited to eight locations within the EL29018 area to the west of the Maryvale Hills. This area is characterised by low gradients. The soils in the exploration lease EL29018 fall within soil classes B43 (Rudosols), Nb19 (Sodosols), Nb25 (Sodosols) and LD1 (Calcarosols).

The site survey found that B43 dominates the investigation sites within Proposal area EL29018. Localized water erosion was occurring at sites CNP03, S11-grasslands and S08 indicating a potential for further erosion with disturbance. Linear structures within the sand dunes and hill slopes which were present across EL29018 would have the potential to cause erosion. The drill site soils (CNP01, CNP02 and CNP03) have high rain splash protection due to generally high soil cover (30-50 %) with moderate below ground contributions (10-20 %) from basal and canopy cover. The ground is also covered with more than 10 % to 50 % litter. S04, S08, S10, and S11 have less ground protection and would be more susceptible to erosional forces.

Alluvial sediments and aeolian sand dominate low lying areas of the Proposal. Deposition of the alluvium is likely to have occurred in the early to mid-Cainozoic with the development of various fluvial systems, notably the Finke and Hugh Rivers. During the Tertiary, the persistence of continental conditions established a period of persistent aridity across Central Australia, prompting the development of extensive hard crusts.

Ongoing aridity into the Quaternary lead to the development of sand dunes across the south-eastern extent of the basin and ultimately the modern day environment (Lloyd and Jacobson 1987). A more detailed assessment on soil conditions in the Proposal can be found in a previous Soils Investigation Report (Low Ecological Services 2013). The implications of soil type to erosion potential and increased sediment loads in down-gradient watercourses is covered in Section 0.

9.3.2 Vegetation

The Proposal area contains 17 different vegetation formations, including forests, woodlands, shrublands, palmlands, grasslands, forblands and an inland salt lake. Forty-two different vegetation types occur across the 17 vegetation formations (DLRM 2011). The dominant vegetation type across much of the Proposal area is Hard Spinifex (*Trioda basedowii*), Low Open Hummock Grassland with an open shrubland of Desert Cassia (*Senna artemisiodes* subsp. *filifolia*), Mulga (*Acacia aneura*), Witchetty Bush (*Acacia kempeana*), *Aristida holathera* and *Allocasuarina decaisneana* (DLRM 2011) (see Plate 9.2 and Plate 9.3).



Plate 9-2 *Trioda basedowii*



Plate 9-3 *Acacia aneura*

Several ephemeral creeks (refer to Section 9.4.8) intersect the Proposal area and are lined by riparian woodlands, comprising:

- River Red Gum (*Eucalyptus camaldulensis* var. *obtusa*) Woodland, containing Coolabah (*Eucalyptus coolabah* subsp. *arida*) with an understorey of Couch (*Cynodon dactylon*), Silky Browntop (*Eulalia aurea*) and Spiny Sedge (*Cyperus gymnocaulos*); and
- Coolabah Woodland, with an understorey of Lignum (*Muehlenbeckia florulenta*), Mulga, Desert Cassia, Water Clover (*Marsiliea spp.*), Couch and Buffel Grass (*Cenchrus ciliaris*).

Given their proximity to waterways, and the presence of River Red Gum and Coolabah, it is likely that these vegetation communities could be partially dependent on the subsurface presence of shallow groundwater.

9.3.3 Climate

Southern NT is characterised by a semi-arid to arid climate with hot dry summers and mild winters (Coffey 2012). Historic rainfall, temperature and evaporation data for the general area was acquired from the Bureau of Meteorology (BoM) for the Alice Springs Airport weather station (BoM: 015590), which is located 113 kilometres north of the Proposal area. The monthly rainfall and temperature dataset extends from January 1940 to July 2016. The mean daily evaporation record extends from 1959 to 2016.

The proponent also owns and operates an Automated Weather Station at the proposed Chandler Facility. However, this meteorological dataset is limited to 12 months and is therefore, not used to define long term or seasonal climatic trends but does provide valuable baseline information for the Proposal area.

9.3.4 Rainfall

The Bureau of Meteorology (BoM) rainfall gauges in the general area are listed in Table 9-6**Table 9-6**. The nearest rainfall gauge to the Proposal area is located at Maryvale, approximately 21 kilometres north-east of the Chandler Facility. The record at Maryvale and adjacent sites contains a significant proportion of data gaps (> 20% of missing data).

Data from BoM stations within 25 kilometres of the mine site, namely Maryvale and Idracowra indicates that long term mean annual rainfall at the proposed mine site is likely to be approximately 204 millimetres (mm) (Table 9-6). Annual rainfall totals are highly variable from year to year and almost 50 percent of annual rainfall can occur within a single month, with rainfall greatest during monsoon months (November to March) and below regional averages during dry months (April to September).

The total annual rainfall recorded at the Alice Springs Airport weather station (BoM 015590) ranges from 76 mm to 782 mm (over the 74-year monitoring period), with an annual mean of 283.5 mm.

Table 9-6 Rainfall gauge data

Gauge number	Name	Latitude	Longitude	Record start	Record end	Record length (years)	Distance from Chandler (km)[22]	Mean annual rainfall (mm)[23]
15519	Palmer Valley	24.75	133.23	1953	Open	63	74	253.5
15524	Idracowra	24.99	133.79	1950	Open	66	25	203.6
15536	Maryvale	24.67	134.07	1948	Open	68	21	205.3
15532	Henbury	24.55	134.25	1897	Open	129	77	224.2
15590	Alice Springs Airport	23.80	133.89	1940	Open	76	113	283.5
	Tellus AWS			2015	Open	1.5	0	136.4

Meteorological monitoring has been performed at the Proposal site since 31 May 2015. An automatic weather station (AWS) collects precipitation data on a continuous basis. Hourly average data collected between 5 November 2015 and 31 January 2017 have been reviewed with a discussion provided below.

The Proposal site received at total of 991 mm of rainfall between 5 November 2015 and 31 January 2017. The distribution of rainfall is presented in Figure 9-6**Figure 9-6**. Distribution of rainfall by season is presented in Table 9-7. Maximum daily rainfall of 136 mm was observed during December 2015, with the average rainfall during the summer months being the highest of all seasons. Lowest maximum and daily average rainfall was observed during the winter months at the Proposal site.

Table 9-7 Observed daily maximum and average rainfall at Chandler - 5 November 2015 to 31 January 2017

Season	Daily rainfall (mm)	
	Maximum	Average
Annual	136.4	2.4
Spring	43.6	1.26
Summer	136.4	5.48
Autumn	34.8	0.89
Winter	19.4	0.60

[22] *Bureau of Meteorology, 2016*
[23] *mm = millimetres*

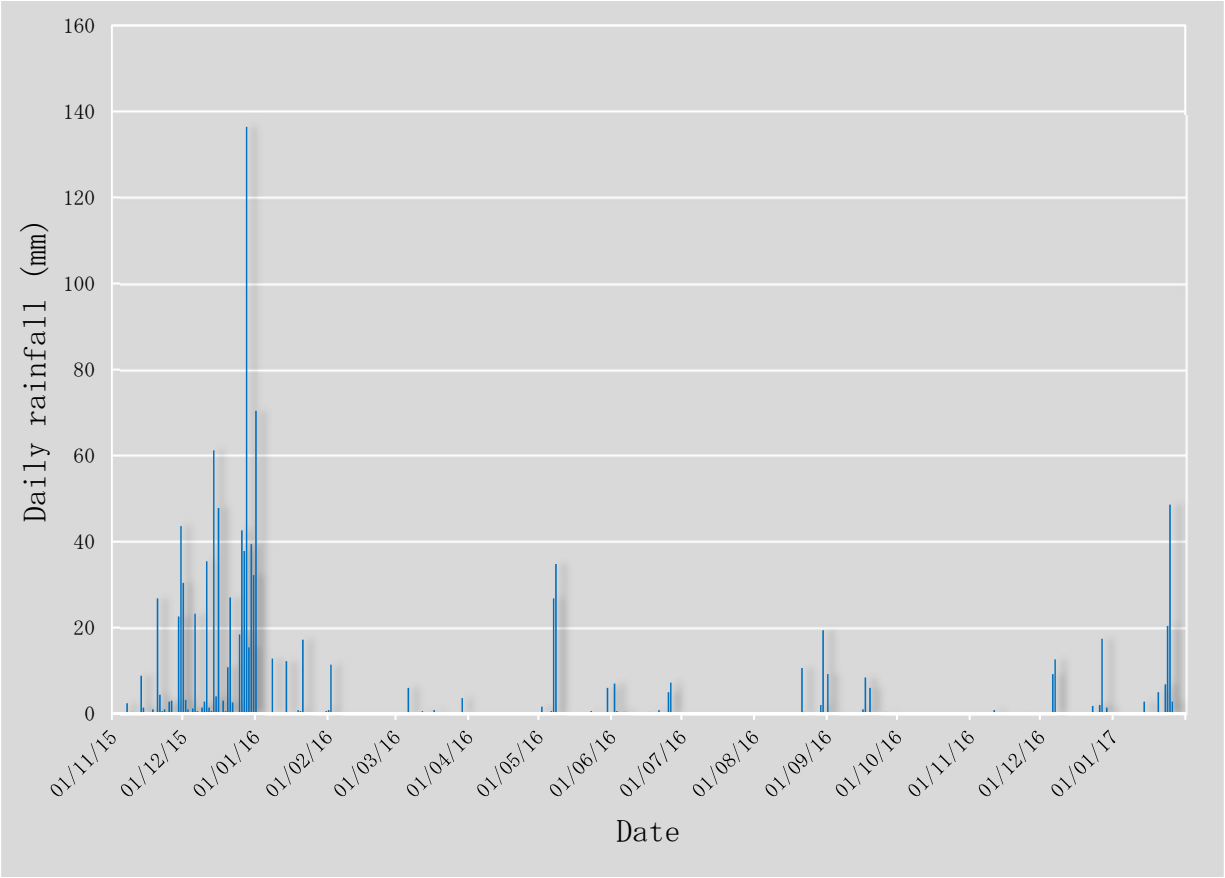


Figure 9-6 Daily average rainfall at Chandler - 5 November 2015 to 31 January 2017

Monthly average rainfall recorded at the Chandler AWS is shown in Table 9-8**Table 9-8**. As expected, the highest rainfall occurred in the wetter months (November to January). Minimal rainfall was recorded at the site in the drier months (April to July).

Table 9-8 Monthly average air temperature, rainfall and humidity at the Chandler AWS

Month	Air temperature (° C)			Relative humidity (%)	Precipitation (mm)
	Average	Maximum	Minimum	Average	Total
November 2015	31.4	41.8	20.7	15.7	120.2
December 2015	29.5	41.5	17.5	37.2	581.2
January 2016	29.2	41.0	17.0	38.9	114.8
February 2016	31.1	43.1	18.5	24.4	12.2
March 2016	28.7	39.9	14.2	39.3	11.2
April 2016	24.4	36.4	9.5	28.7	0.2
May 2016	18.8	32.4	6.3	53.8	70.4
June 2016	14.5	25.5	2.1	69.5	22.4
July 2016	13.1	29.3	-2.0	54.4	0.4
August 2016	15.4	29.6	-0.3	44.3	32.6
September 2016	18.2	32.9	9.1	50.1	25.8
October*	-	-	-	-	-
November 2016	31.4	41.8	20.7	15.7	120.2
December 2016	29.5	41.5	17.5	37.2	181.2
January 2017	31.8	42.0	22.1	41.2	86.6
Average	**24.36**	**37.09**	**11.06**	**39.33**	**74.92**

**AWS instrumentation failed for the month of October*

Rainfall intensity

Average Recurrence Intervals (ARIs) have been determined by the BoM (Table 9-9). ARIs show predicted rainfall intensities for a range of storm durations and average recurrence intervals. For example, a 100- year ARI 24-hour rainfall intensity (7.4 mm/hr) is almost twice the 10-year ARI 24 - hour rainfall intensity (3.87 mm/hr) and one eighth of the 100-year ARI 1-hour rainfall intensity (55.7 mm/hr). In general, higher rainfall intensity occurs over short durations, also higher rainfall intensity events are a less frequent occurrence than lower intensity rainfall events.

Table 9-9 Rainfall intensity, frequency and duration data

Duration	1 year (mm)	2 year (mm)	5 year (mm)	10 year (mm)	20 year (mm)	50 year (mm)	100 year (mm)
5 mins	41.8	56.5	82.7	99.9	122	152	176
6 mins	39.0	52.7	77.2	93.2	114	142	164
10 mins	32.2	43.4	63.6	76.8	93.6	117	135
20 mins	24.1	32.5	47.4	57.2	69.4	86.5	100
30 mins	19.8	26.7	38.8	46.8	56.8	70.7	81.8
1 hour	13.3	18.0	46.3	31.7	38.6	48.1	55.7
2 hours	8.37	11.3	16.9	20.5	25.1	31.5	36.7
3 hours	6.25	8.51	12.8	15.7	19.3	24.4	28.5
6 hours	3.75	5.15	7.93	9.83	12.2	15.6	18.4
12 hours	2.28	3.15	4.93	6.17	7.72	9.94	11.8
24 hours	1.42	1.97	3.08	3.87	4.84	6.24	7.4
48 hours	0.885	1.22	1.89	2.36	2.94	3.78	4.47
72 hours	0.639	0.879	1.37	1.71	2.13	2.74	3.24

Source: Bureau of Meteorology

9.3.5 Rainfall recharge

Analysis of wet and dry periods is important to appropriately characterise seasons and climatic variability. This information can be used to analyse groundwater recharge responses and consider potential impacts.

Analysis of dry and wet periods can be completed using the statistical technique of cumulative deviation from the mean (CDFM). CDFM is commonly used to relate groundwater level fluctuations to trends in rainfall and can also be used to assess trends in long-term monthly and annual rainfall fluctuations. The CDFM method subtracts the actual rainfall over a defined period from the long-term mean rainfall of the same period (Ferdowsian and McCarron 2001; Yesertener 2007).

Figure 9-5 presents the cumulative departures from the mean for the Alice Springs Airport weather station. The upward or downward trend in the curve indicates a period of above or below average rainfall respectively; these are marked on the graph as wet or dry periods

Figure 9-7 shows defined wet and dry periods over the 65-year rainfall record. Four apparent dry periods with below average rainfall are observed over this period (1948-1973; 1983-1999; 2001-2009; 2011- current). Conversely, three defined wet periods are visible within the dataset (1973-1983; 1999-2001; 2009-2011).

The bulk of the monitoring period shows below average, or dry, conditions. This suggests that the above average, or wetter periods, comprise significant rainfall events such that the mean is skewed to portray average rainfall as 'dry'.

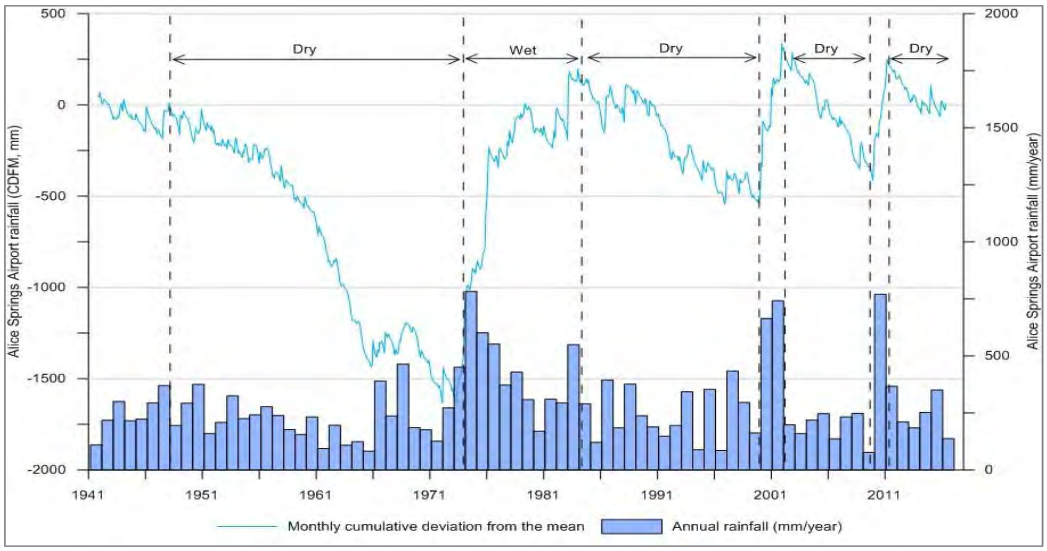


Figure 9-7 Rainfall - monthly cumulative deviation from the mean

9.3.6 Evaporation

Characterising evaporative losses is important to understanding the mechanisms for groundwater recharge and the regional climatic conditions. Daily mean pan evaporation data is available from the Alice Springs Airport weather station (BoM 015590). Pan evaporation is a measurement that

integrates several climatic elements, including temperature, humidity, rainfall, solar radiation, and wind. The Alice Springs Airport weather station has a reliable pan evaporation dataset extending from 1959 to 2016 (approximately 57 years) for comparison with historic rainfall for the area.

The annual average pan evaporation measured at the station is approximately 3,147 mm, more than 42.5 times the monthly average rainfall and 23 times the annual average rainfall.

The greatest evaporation rates occur from October through to March, as evaporation is significantly influenced by temperature and solar radiation over the summer period. On average, evaporation exceeds rainfall by about 4.5 times in each month of the year.

9.3.7 Surface water

Regional setting

Three categories of surface water systems exist across the NT:

- Permanent or perennial surface water systems–these are ever-present and are typically observed as rivers, lakes, springs and swamps.
- Semi-permanent or ephemeral surface water systems–these systems hold water for part of the year and are typically observed as small creeks, lagoons, waterholes or low lying areas across arid zones.
- Engineered surface water systems–these systems are widespread across the NT and typically consist of dams, turkey nests or engineered swamps that provide a source of water for stock and domestic purposes.

The NT is represented by four major drainage divisions (Figure 9-8). Drainage divisions are topographically controlled and direct regional surface water flows to either a major sea or inland basin. There are 35 river basins represented across the NT. Each drainage division has numerous river basins, which form the catchment areas for major surface water systems. The Proposal lies within the Finke River Basin within the Lake Eyre Drainage Division.

The low average rainfall and extensive aridity in southern NT contributes to a lack of permanent watercourses in the vast majority of the land surface. Most watercourses are ephemeral with particularly infrequent flows, reflecting the rainfall distribution. Clay pans, salt pans, rivers and flood outs are dry for the majority of the year, flooding during irregular intense rainfall events. When flowing, rivers drain inland (athalassic) rather than to the sea. Watercourses originate where surface runoff discharges into defined channels, converging to form ephemeral rivers.

Despite their variable flow regimes, these ephemeral surface water systems provide a crucial source of water for arid landscapes. They support significant aquatic and terrestrial biodiversity, including many unique species

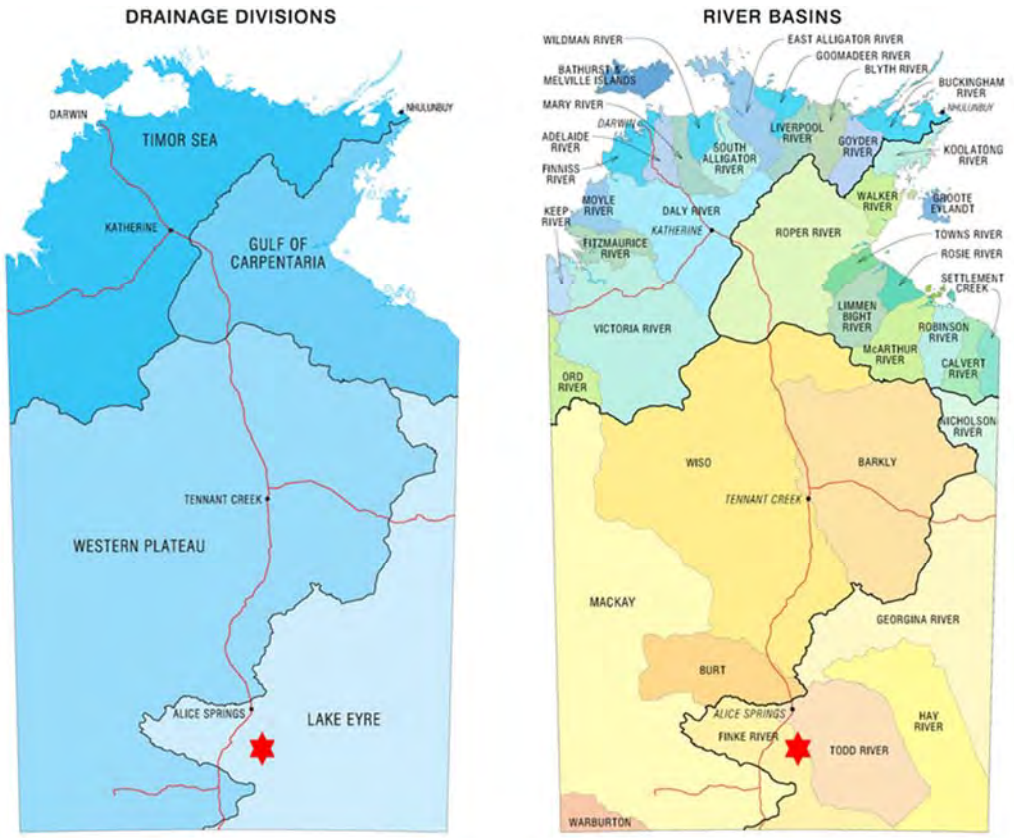


Figure 9-8 NT Drainage Divisions and River Basins

Approximate Study Area location; Source: NT Government, 2016

The Study Area also lies within the Lake Eyre Basin bioregion (Figure 9-9a). The Lake Eyre Basin bioregion covers an area of about 1.31 million square kilometres of central and north-eastern Australia, which is almost one-sixth of the country (Miles *et al*. 2015).

It extends across parts of Queensland, South Australia, New South Wales and the Northern Territory and incorporates the whole of the Lake Eyre drainage basin. The Lake Eyre Basin bioregion includes four subregions: the Galilee, Cooper, Pedirka and Arckaringa subregions. The Pedirka sub-region lies approximately 100 kilometres down-gradient from the Study Area (see Figure 9-9b).

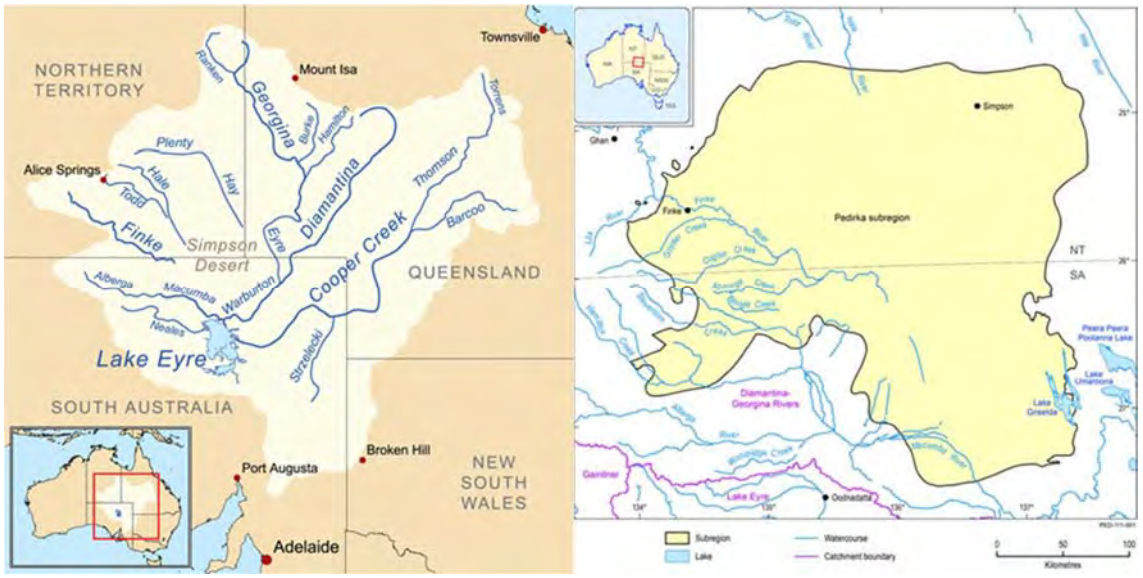


Figure 9-9 (a) Lake Eyre bioregion and (b) Pedirka subregion
Source: Miles et al., 2015

The Finke and Hugh Rivers are the major ephemeral surface water features in the Finke River Basin (Figure 9-10). The headwaters of the Finke and Hugh Rivers rise in the MacDonnell Ranges and basement rock hills to the west of Alice Springs. The Finke is the longest and largest of the Desert Rivers in Central Australia and passes the Proposal area 20 kilometres to the south and its catchment continues into northern South Australia. Major flows only occur along the Finke River about every decade. In some years flood flows in this river may occur along several stretches of the river but never meet. South of the Proposal area, the river flows on average less than once per year generally over summer but occasionally during winter.

In 2016, there have been four flows south of the Proposal area a minor flow in January and moderate flows in February, May and August. The Finke River recharges aquifers at specific localities along its length but it also picks up saline water from groundwater discharge zones. During major floods it carries and recharges good quality water to aquifers but during small flows in some catchments it carries salt water in many locations. A large volume of groundwater is stored and moves through its sandy and sandy clay river bed. These sediments fill an eroded river valley of more than 1 000 kilometres long, often several hundred metres wide and up to 30 metres deep.

The Hugh River is a major tributary of the Finke River, its junction is 30 kilometres to the south-east of the Proposal area and it also recharge aquifers along its length. Unlike the Finke River it is only around 500 kilometres long but unlike the Finke River is known for its excellent quality water. It provides the good quality water to the aquifer which provide the water supply to Titjikala and Maryvale Homestead. This aquifer has excellent quality groundwater in storage unlike the groundwater resources at the Proposal area which are saline (refer to Chapter 8 for more information).

Major flood flows in the Todd River dissipate into flood outs in the Simpson Desert 100 kilometres east of the Proposal area. Extensive data on streamflow in the Todd River though Alice Springs and

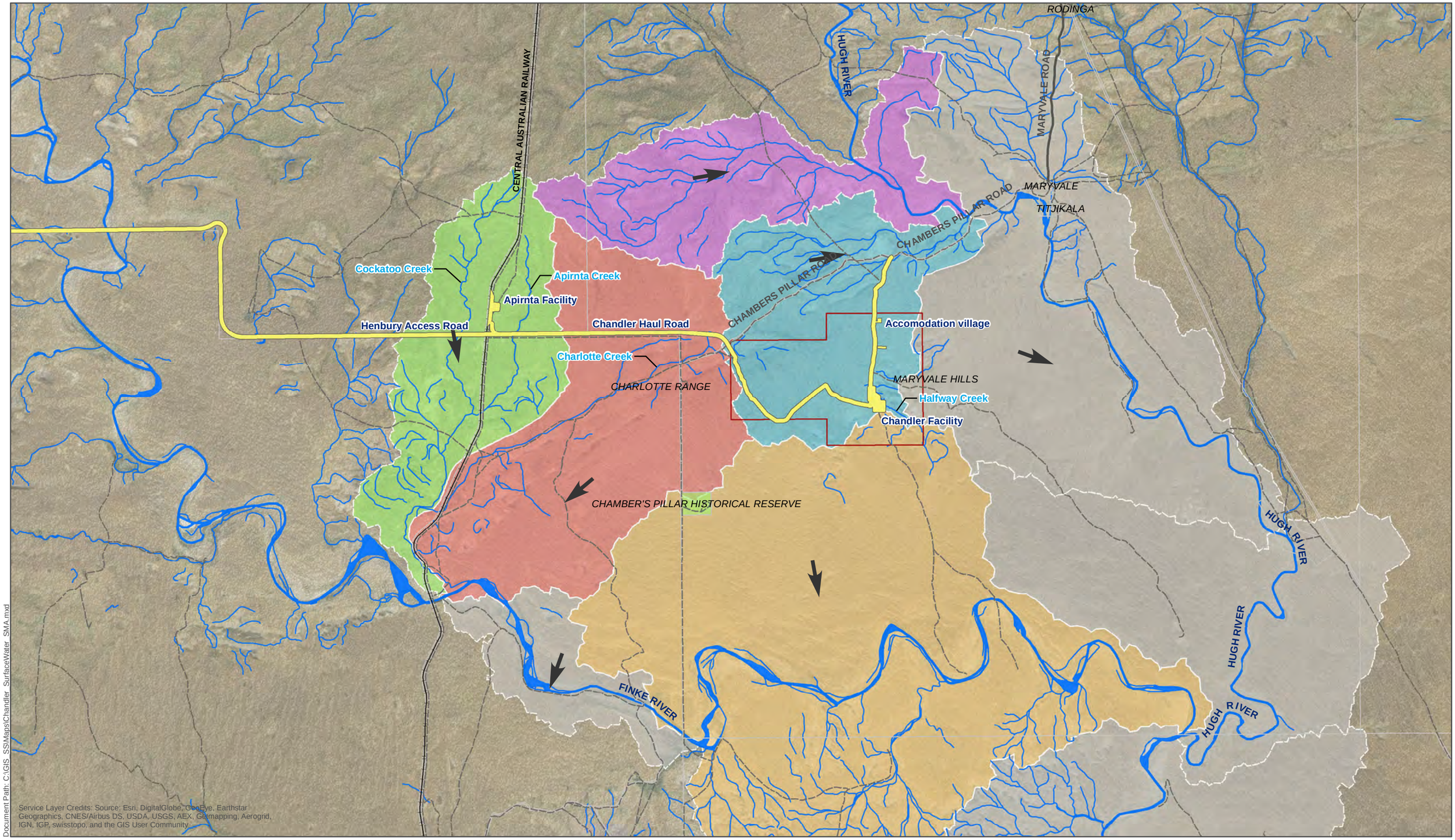
from multiple stream gauging and climate stations in its upstream catchment plus the 144 year rainfall, temperature and evaporation record for Alice Springs provide very useful knowledge on the nature of the local arid zone stream flow hydrology, catchment yield and other surface water characteristics which are also relevant to the Proposal area.



Figure 9-10 Major rivers surrounding the Proposal site. Aerial imagery sourced from ESRI partners

Both rivers originate at the foothills of the MacDonnell Ranges up to 200 kilometres north-west of the Proposal area. The Hugh River is located to the north of the Proposal and flows south-easterly where it joins for Finke River approximately 30 kilometres south-east of the Proposal.

The Finke River flows in a south-easterly direction to the south of the Proposal. Several ephemeral drainage lines discharge to the Finke River and Hugh River along the reaches adjacent to the Proposal area. These are predominantly topographical controlled by various sand dunes, ranges and outcropping basement rock visible across the Proposal area. For the purposes of this study, it was necessary to define the spatial extent of the assessment. A sub-catchment delineation map has been produced for the Study Area (see Figure 9-11). The Study Area has been defined as potential surface water receptors defined as those watercourses that drain the Proposal area and / or could be impacted by the proposed activities downstream. By definition, the Study Area is therefore larger than the Proposal area.



Document Path: C:\GIS_SS\Maps\Chandler_SurfaceWater_SMA.mxd

N

4 2 0 4 Kilometers

Coordinate System:
GDA 1994 MGA Zone 53

Legend

- Proposed development footprint
- Watercourse
- Pastoral boundaries
- Mining Lease Area
- Catchment A - 21,662 ha
- Catchment B - 18,986 ha
- Catchment C - 33,401 ha
- Catchment D - 81,707 ha
- Catchment E - 20,842 ha
- Flow direction

Figure 9-11
Catchment connectivity within the study area

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; USGS, SRTM elevation, 2000; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller

To define the spatial scale of this assessment the potential connectivity from this sub-catchment delineation was used to identify the following water features which would be considered:

- All dams within or down-gradient from the Proposal area.
- All drainage lines within the Proposal area.
- The Finke River from the Stuart Highway Crossing to the confluence.
- The Hugh River from the Rail Crossing to the confluence with the Finke River.

It should be noted that this sub-catchment delineation only refers to potential connectivity based on coarse-scale topography and has not been ground-truthed. In particular, anecdotal evidence suggests that the grey-shaded sub-catchment is not connected to the Hugh River.

Regional Flow characteristics

Surface water flow is ephemeral in all watercourses in and around the Proposal area, with the Finke, Hugh and Palmer Rivers running dry for long periods of time. Flow events are generally driven by large rainfall systems associated with monsoonal rain depressions from northern Australia or extreme weather caused from cyclonic lows. Small flow events occur with annual to bi-annual regularity, often only resulting in a section of each river flowing.

This is reflected in flow duration curves (see Figure 9-12), where a flow of 1 m^3/s is exceeded for only 10.4 % of the Finke River record and 8.1 % of the Hugh River record. No evidence of ongoing baseflow component can be seen in flow records, consistent with visual observations of dry river beds. Low or no-flow conditions dominate for approximately 80 % of the year on the Finke and Hugh Rivers, and 90 % of the year on the Palmer River[24].

Larger flow events (anecdotally known as those where a river flows simultaneously along its entire length (NT Government 2012)[25]) can result in rivers running for weeks as opposed to days. In February 2000, the Stuart Highway Bridge over the Finke River was submerged for approximately one week (DoIRD 2003). A decision was made to replace this bridge after it had been submerged under floodwaters 13 times between 1969 and 2003.

Occasionally multiple larger events occur in the same year (such as recorded on the Finke River in 2010 or on the Hugh River in 2000). Table 9-5 lists flow rates of selected floods measured in flow gauging records for the Finke, Hugh and Palmer Rivers[26].

---

[24] *Note that measurement uncertainty at the Palmer and Hugh Rivers prevent identification of flows less than 1.4 and 0.3 m^3/s respectively.*

[25] *In the case of the Finke River, this refers to the region between its Hermannsburg headwaters through to the flood-out area at Andado, downstream of the Finke township (approximately 100km straight line distance down-gradient from the CSMP Site Area).*

[26] *Note that as these rivers are ephemeral, opportunity to assess rating curves is restricted and therefore large flood flow rates may be of limited accuracy.*

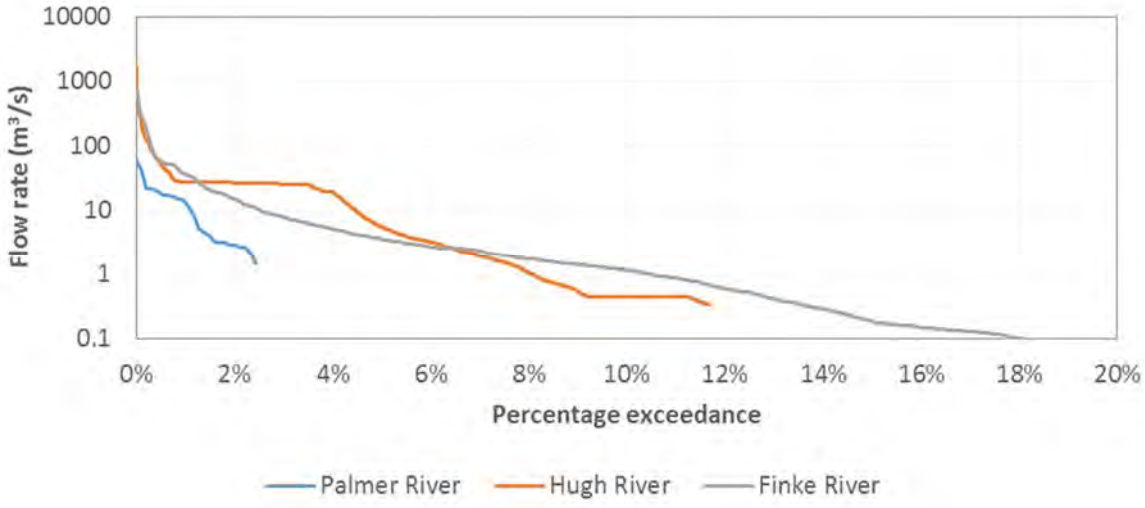


Figure 9-12 Percentage of flow record in which given average-daily flow rate is exceeded

The maximum water depth recorded on the Finke River at Stuart Highway was 9.7 metres, while on the Hugh River was 6.7 metres (NT Government 2016). Channel banks are approximately five metres and two metres high, respectively, at these locations. It follows that bank overtopping does occur but relevance to the sections of both rivers closest to the Proposal Area are unclear due to differences in bank heights, bed gradient and cross-sectional profile.

Table 9-10 Flow rate of significant floods, as measured at Stuart Highway gauging stations

River name	Date and daily mean flow
Finke River - (records commenced in 2004)	10 Jan 2010 – 755 m^3/s 1 Mar 2010 – 584 m^3/s
Hugh River - (records commenced in 1972)	18 Mar 1983 – 640 m^3/s 31 Mar 1988 – 1,039 m^3/s 17 Jan 1995 – 629 m^3/s 12 Feb 2000 – 1,667 m^3/s 22 April 2000 – 592 m^3/s
Palmer River - (records commenced in 2010)	22 Feb 2011 – 60 m^3/s 2 Mar 2012 – 42 m^3/s

The township of Titjikala is situated adjacent to Titjikala Creek, a tributary of Hugh River. While this creek is usually dry, it has been known to flood to a depth of one metre, effectively turning the town into an island (ABC 2014). In 2015 a new sewage system was built in Titjikala to address health issues generated when such flooding caused residential septic tanks to overflow (LGANT 2016).

Watercourse types within the study area

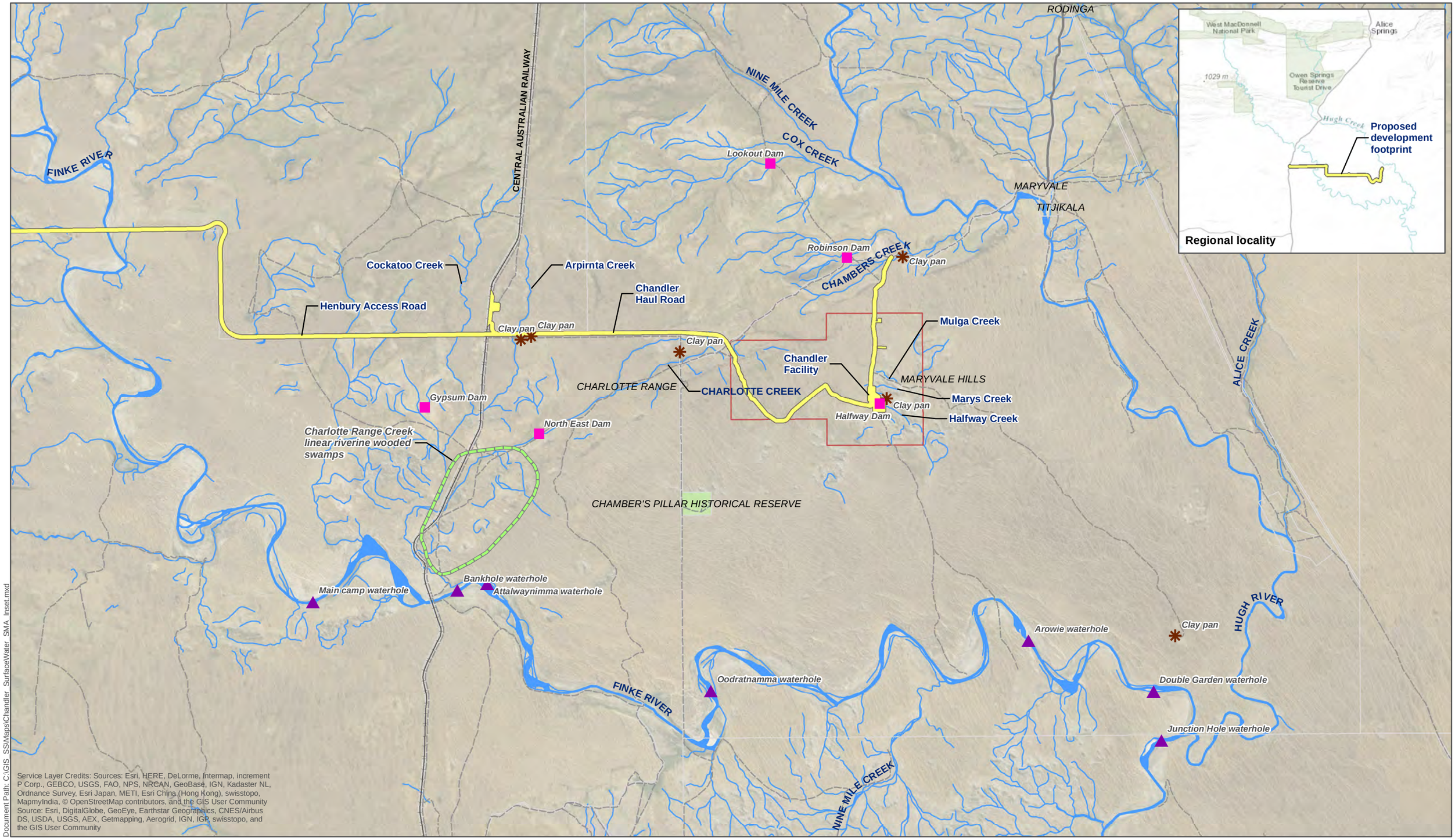
There are six types of surface water present in the Study Area, classified according to wetland types after Duid, 2011:

- Major wooded watercourses (type WL2001) most are sandy channels fringed by River Red Gum (*Eucalyptus camaldulensis*) and / or Coolabah (*Eucalyptus coolabah*). This includes the Finke and Hugh Rivers.
- Temporary generally dry waterholes (type WL1202) occur along the major Finke River. There is little survey or other data regarding how long individual waterholes last. Semi-permanent waterholes on the Finke River within the Study Area but outside of the Proposal area include the following:
    - Main Camp Waterhole.
    - Bankhole Waterhole.
    - Attalwaynimma Waterhole.
    - Oodratnamma Waterhole.
    - Arowie Waterhole.
    - Double Garden Waterhole.
    - Junction Hole Waterhole.
- It is understood that these are not supported by groundwater but rather are refuge pools which slowly evaporate following rainfall events and upstream catchment water delivery. The Hugh River does not contain any waterholes and there are no small creeks, lagoons, or low lying areas within the Proposal area that contain water outside of rainfall event periods.
- Generally dry upland channels (type WU2201) which are ephemeral first-order drainage lines.
- Small freshwater lakes and clay pans (type B1221). Notable examples include Mulga Claypan and Chambers Pillar Creek linear riverine lakes but it is expected that many more of these features exist in the Study Area. Clay pans are hard, bare, unproductive areas created from a loss of cover which exposes the soil surface to raindrop impact and erosion. This leads to surface sealing/crusting and water ponding following rainfall (Wouldiams and Biggs 2010).
- Shrubby / wooded flood prone flats (types F001 / F002) are flood outs receiving present in the Proposal area which are dry most of the time, but infrequent yet sometimes intense rainfall events cause up-gradient arid zone streams to flow for short periods and deliver sheet flow to these areas. They are not wet for sufficient periods to be regarded as a ‘swamp’ or ‘wetland’.

- Dams across watercourses (type A1001) are man-made surface water held in artificial structures is present both within the Proposal area (Halfway Dam) and in the wider Study Area (Gypsum, Lookout, North-East and Robinson Dams).
- There are no lakes, artificial swamps or sewage treatment ponds within the Proposal area.
- There is no permanent or perennial surface water within the study area. There are no lakes, permanent waterholes, springs or swamps, supported by groundwater when there is little or no rain, present in the Proposal area.

A consequence of the short duration flow events and high evaporation of surface lay water in these headwater catchment is that it is difficult to monitor the events. In the absence of data, the following sub-sections detail anecdotal evidence on watercourse functioning for three specific watercourse features within the Study Area:

- Maryvale Hills drainage lines and flood out.
- In-line farm dams.
- Apirnta Creek at rail crossing.



Document Path: C:\GIS_SSMaps\Chandler_SurfaceWater_SMA_Inset.mxd

N

4 2 0 4 Kilometers

Coordinate System:
GDA 1994 MGA Zone 53

Legend

- Proposed development footprint
- Watercourse
- Pastoral boundaries
- Mining Lease Area
- Clay pan
- Dam
- Waterhole

Figure 9-13
Regional surface water courses

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use.
Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; USGS, SRTM elevation, 2000; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller

Halfway dam

Halfway Creek's natural drainage course has been altered by the construction of Halfway Dam. This once flowed north and into a larger flood-out / sediment settlement zone as indicated in Figure 9- 14. The same zone supports indigenous groundcovers, shrubs and trees, some large tree species including Red Gums and Grey Box. However, these terrestrial plant communities have been adversely impacted by the location of Halfway Dam which cuts off the natural (north-westerly) flow of surface water. This is evident by the significant die back, or in some cases, mortality of large trees.

A large sediment trap / basin has been artificially formed on the upstream side of Halfway Dam. When full, it recharges Halfway Dam. It also has an outlet through a constructed embankment. When the basin is full, water flows (south) through an outlet which is approximately five metres above Halfway Creek. Halfway Creek at this point in the landscape is a relatively new surface water feature. The banks of Halfway Creek in this location are actively eroding, caused by livestock grazing.

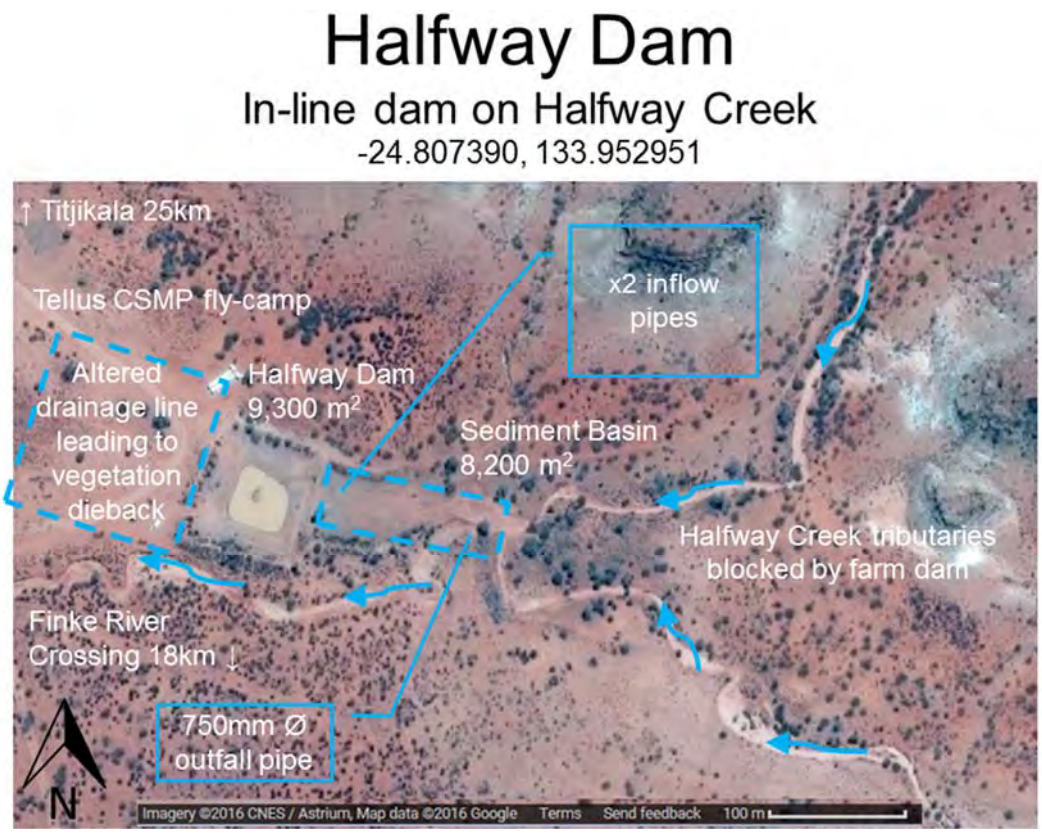


Figure 9-14 Hydraulic characteristics of Halfway Dam

Local hydrology

The Hugh and Finke rivers are large ephemeral surface water systems within the vicinity of the Proposal. These watercourses are considered to be drainage channels that convey surface water flows to discharge areas. Flow events in these rivers are characteristically infrequent. When in flow,

they support permanent wetlands and waterholes that provide internationally significant habitats for water birds and aquatic flora and fauna (Miles *et al.* 2015).

Dryland rivers, such as the Fink River and Hugh River, also support consumptive and recreational water users and are widely used for agricultural and town supplies in inland Australia. These rivers are usually also important to Indigenous peoples with sacred sites and other culturally important requirements (Robson 2008).

Several ephemeral drainage lines discharge to the Finke River and Hugh River along the reaches adjacent to the Proposal area. These are predominantly topographical controlled by various sand dunes, ranges and outcropping basement rock visible across the Proposal area. The Charlotte Ranges to the west of the Proposal are a source of ephemeral drainage for the Finke River, while the ranges to the north of the Proposal (Oliffe Range and James Ranges) drain to the Hugh River.

The low average rainfall and high evaporation in southern NT contributes to a lack of permanent watercourses in the Proposal area and means most temporary watercourses are ephemeral with infrequent high flows during storm events. Watercourses originate where surface runoff discharges into defined channels, converging to form ephemeral rivers. Observations suggest runoff from the Maryvale Hills flows in drainage lines (gullies) westwards towards a flood-out zone (see Figure 9-14). In this area, water is ponded with negligible flow and, evaporation / infiltration into sub-soils gradually diminish the surface area.

Maryvale Hills

The drainage lines coming off the Maryvale Hills to the east of the Chandler Facility are gully like features. They are deeply incised, capable of carrying small to medium angular to sub-angular rocks through the mid slopes and towards the lower slopes where they enter the sediment settlement zone. Rocks in the mid to lower slopes are typically 10 cm x 7 cm with and some much larger than this (up to 20 cm x 20 cm) (see **Plate 9-4**). This indicates that water flows off the steeper slopes of Maryvale Hills are capable of transporting medium sized rocks.

Riparian vegetation in the form of juvenile to mature Mulga, Mature Desert Oak, Salt bush, Cassia and Paper Daisy dominate the banks of the gullies. Mary's Creek is the largest system of all the gullies followed by Oak Gully. Dingo, Ridey, Roo and Snake Gully are all small by comparison and do not consist of defined channels with banks like Mary's Creek and Oak Gully do (see **Plate 9-4** and **Plate 9-5**).



Plate 9-4 Snake Gully colluvial zone and deeply incised gully

Plate 9-5 Mary's Creek – note the alluvial sands, defined embankment and riparian vegetation



Mary's Creek is the largest system of all the gullies followed by Oak Gully with Dingo, Ridey, Roo and Snake Gully all small by comparison and not consisting of a defined channel with banks. The drainage lines all flow westwards off the Maryvale Hills but the stock access road leading to Halfway Dam (and the Tellus camp site) acts as a barrier to westerly flows. Instead of flowing west towards the contiguous flood out zone as topography would have originally dictated, lower flows now tend to flow northeast along the road to an area of depression approximately 500 m northeast of Mary's Creek. A large clay pan lies between Halfway Creek and Roo Gully (refer to Figure 9-15).

Approximately 1 km beyond the flood out zone, in a north-westerly direction, lies a desert dune and swale system. The swales contain distinct plant community groups dominated by prostrate Daisy's and Millet Grass. The dunes probably act as a barrier to flows from the Maryvale Hill gullies and the plants instead rely heavily on locally sourced water from run-off out of the dunes. Conversely, the dune system also acts as a barrier to flows off the Charlotte Range (in the north-west). The Charlotte Range is located along the entire south section of Chambers Pillar Road. It too acts as a barrier to overland flows and acts as a barrier to flows between the Hugh River and the ChandlerFacility

As stated above, the drainage lines all flow westwards off the Maryvale Hills but the stock access road leading to Halfway Dam (and the Tellus accommodation village) acts as a barrier to westerly flows. Instead of flowing west towards the contiguous flood out zone as topography would have originally dictated, lower flows now tend to flow north-east along the road to an area of depression approximately 500 m north-east of Mary's Creek. A large clay pan lies between Halfway Creek and Roo Gully (Figure 9-15).

Approximately one kilometre beyond the flood out zone, in a north-westerly direction, lies a desert dune and swale system. The swales contain distinct plant community groups dominated by prostrate Daisy's and Millet Grass. The dunes probably act as a barrier to flows from the Maryvale Hill gullies and the plants instead rely heavily on locally sourced water from run-off out of the dunes.

Conversely, the dune system also acts as a barrier to flows off the Charlotte Range (in the north-west). The Charlotte Range is located along the entire south section of Chambers Pillar Road. It also



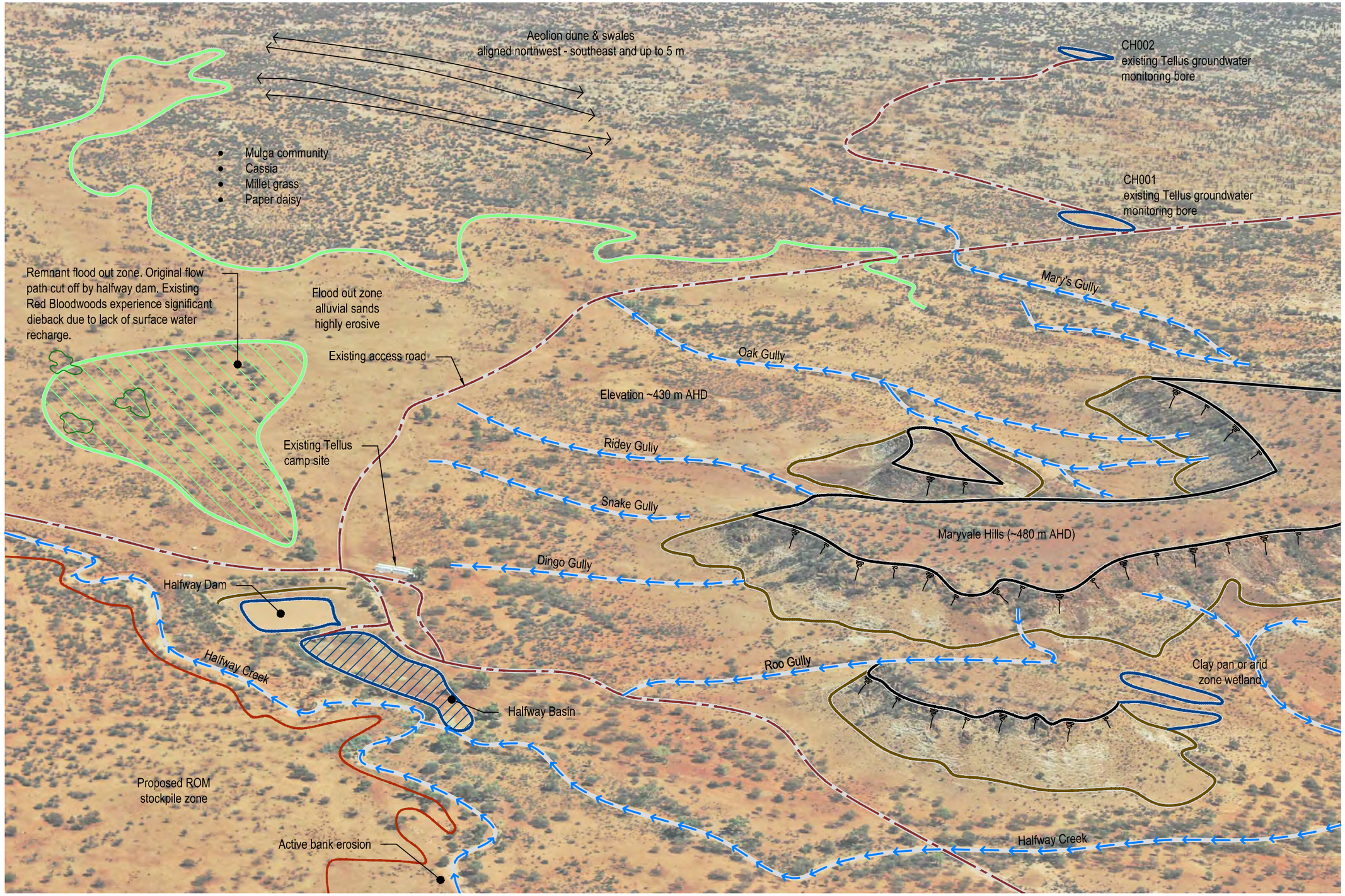
acts as a barrier to overland flows and acts as a barrier to flows between the Hugh River and the Chandler Facility. A more detailed fluvial geomorphology appraisal of Mary's Creek can be found in the BECA report in Appendix R.

No breakthrough to the dune area to the north of the sub-catchment is observed, with water in this area locally-derived from runoff from the adjacent dune system. Furthermore, no connectivity between the dune area and the Hugh River to the north is anticipated. No assessment downstream from the confluence between the Hugh and the Finke is deemed necessary because the flow contribution from the Proposal area to flows below this point is considered to be insignificant.

Whilst the flow of major rivers surrounding the Proposal is relatively well monitored, local drainage lines immediate to the Proposal area are poorly understood owing to its remote location and little variation in land use over the last century. Channels range from the poorly defined and transitory to well established stream beds, such as those within escarpment valleys.

Stream catchments surrounding the Proposal area are generally between 6 and 100 km^2, in contrast to catchment sizes between 3,100 and 7,500 km^2 for the Finke, Hugh and Palmer Rivers at Stuart Highway crossings. As a consequence, the storm duration for the critical flow rate events would be shorter, and flooding would be more heavily driven by localised rainfall events.

As with rivers such as the Finke and Hugh, rainfall and evaporation patterns would cause local channels to be dry throughout a large part of the year. In various regions, channels drain across flood plains, providing increased opportunity for evaporation of flow due to the higher surface area to volume ratio. In these downstream areas, connectivity is often unclear. Nevertheless, assuming flow patterns are analogous to those observed in river records, flood magnitudes in local channels are expected to be significant.



Legend

- Existing access road
- Watercourse
- Vegetation
- Indicative batter slope

Figure 9-15
Conceptual Site Hydrological Model

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use.
Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data supplied by Department of Land Resource Management.
Copyright Northern Territory of Australia.
Created by:apmiller

Apirnta Creek tributary rail crossing

Apirnta Creek provides a possible hydrological connection from the upstream catchment to the Finke River system. Apirnta Creek lies approximately two kilometres to the east of the Central Australian Railway and drains across the existing access road (soon to be named Chandler Haul Road) at 10 kilometres chainage from the upstream source. It flows towards a railway culvert at 16.5 km and continues in a westerly direction, joining another tributary at 17 kilometres until it flows south and eventually towards the Finke River, some 35 kilometres downstream at the Attalwaynimma Waterhole.

One of the tributaries of the Apirnta Creek flows along the east side of the rail line embankment and crosses the rail line under a 3.3 BRLEN deck culvert at rail chainage reference 1212.238 kilometres (*pers comm.* Peter Taylor, Genesee & Wyoming Australia 2016). It also receives inflow from the west side of the rail line via twin 700mm Ø circular culverts.

This site currently has significant erosion issues. The history of the site is not clear but it appears that the rail embankment concentrates the flow line and an embankment has been placed across the original drainage course, diverting the flow under the rail line.

In-line farm dams

Five in-line drainage dams have been identified, one within the Proposal area (Halfway Dam) and four others in the Study Area (Gypsum, Lookout, North-East and Robinson Dams). Schematics and a brief description of these dams are provided in Appendix R.

9.3.8 Water quality

Limited water quality data exists for Finke region in the scientific literature due to the unreliability of surface water flows and the remoteness of the area. Water quality criteria used for the Proposal is set out in Section 9.2.4.

Existing mine related water quality stations are outlined in Figure 9-1. The data collected from these stations were compared against the trigger values for 95 % freshwater aquatic ecosystem protection (Appendix R,) and primary industries livestock protection (Appendix R).

Due to the hardness of the water sample data, hardness modified trigger values (HMTVs) for cadmium, chromium, copper, lead, nickel and zinc were develop as outlined be the ANZECC guidelines. These HMTVs better represent the site-specific bioavailability of these metals in surface water on-site.

At the NT stations, the comparison of the surface water samples with physical and chemical guidelines showed the following:

- For aquatic ecosystem 95 % protection, electrical conductivity exceeded the guideline values. The surface water was found to be hard and the pH samples was either equal to or greater than the pH trigger limits. The dissolved oxygen was only sampled once at station G0050116 and was

below the guideline. Total dissolved solids (TDS) was below the trigger values, except at stations G0050119 and G00140 where samples taken exceeded the guideline. Total suspended solids (TSS) was measured once at station G0050115 and exceeded the guideline value. Similarly, turbidity was measure once at station G50050116 and was greater than the trigger values.

- For livestock protection, both calcium and fluoride was below the trigger values required to cause adverse effects in livestock protection. However, nitrate results were above the guidelines. Sulphate was below trigger values, accept where it exceeded the trigger value once at station G005119. The TDS was below the guideline except at sites G0055119 and G0055140.

The Chandler Facility surface water sample comparison showed the following:

- For aquatic ecosystem 95 % protection, electrical conductivity was below the guidelines at CS005011, CS005013 and CS005021, but exceed the trigger values at CS005060 and CS005071. The water was found to be hard, with pH and turbidity results exceeding the guideline values at stations CS005060 and C005071. TDS and TSS were below the guideline values at station CS005060 and CS005071. Aluminium, chromium, copper, manganese and silver showed a split across the Chandler Facility water quality data, either exceeding or measuring below the guideline. Arsenic, boron, cadmium, mercury, nickel, nitrate, lead and selenium were lower than the guideline values. Zinc exceeded the guideline value, except at station CS005060 and CS005071. Ammonia was below the guideline value at sites CS005060 and CS005071. Phosphate was equal or greater than the trigger value at sites CS005071 and CS005060, respectively.

- For livestock protection, TDS was below the guideline values for livestock protection at station CS005060 and CS005071. Arsenic, boron, calcium, cadmium, cobalt mercury, nickel, nitrate, lead, selenium and uranium were lower than the guideline values. Aluminium, chromium, copper, manganese and silver showed a split across the Chandler Facility water quality data, either exceeding or measuring below the guideline. Molybdenum and zinc exceeded the guideline value, except at station CS005060 and CS005071. Ammonia was below the guideline value at sites CS005060 and CS005071. Fluoride was below the guideline value across each Chandler Facility site and sulphate was below the guideline value across all Chandler Facility sites, except CS005060. Phosphate was equal or greater than the trigger value at sites CS005071 and CS005060, respectively.

From the above results, NT monitoring site would be suitable for aquatic ecosystem protection, but may have adverse effects for livestock production due to the level of nitrate at these stations. At the Chandler Facility stations, the results showed split results for several chemical and physical stressors across the station and may be due to the irregularity of the rainfall events in the region. Overall the results, suggest CS005060 and CS005071 would be suitable for aquatic ecosystem protection, but all sites within the area may not be suitable for livestock production, due to the levels of metals within the surface water.

Guideline sediment values were not exceeded for any of the metals tested at any site. Electrical conductivity (1:5 deionised water leach) were low at all sites, particularly CS005013 and CS0041, at 11 and 19 µS cm^{-1}, respectively. Total organic carbon in sediments were also low at CS005013, in

addition to GEOM03, at 520 and 890 mg kg^{-1}, respectively. Presumably this was due to the high quartz content present in bed sediments at these two sites.

The Water Management Plan (see Appendix Q) defines sediment quality trigger values which would prompt a further investigation into source / activity and mitigation and contaminant limits which should not be breached at any time. It is recommended that sampling be continued at all sites on a bi-annual frequency (i.e. dry and wet season) during construction and operation phases

In general, cease-to-flow causes water to retract to a series of connected or disconnected waterholes where water quality is driven by processes such as evaporation, groundwater influence and the concentration or precipitation of compounds (Miles *et al*. 2015). Water quality conditions at a local scale include low dissolved oxygen levels, high temperatures, increasing salinities, hardness, alkalinity and cations (Sheldon and Fellows 2010).

Water quality during flooding flows is driven by the large volumes of catchment runoff. Flooding entrains organic carbon and nutrients from the productive floodplain areas into the river channels to support food webs (Miles *et al*. 2015). A unique feature of some Australian dryland rivers is their permanent high mineral turbidity, which is characteristic of the local geologies and land use (Sheldon and Fellows 2010). This leads to fine clays in suspension even under no-flow conditions (Bunn *et al.* 2006).

Analysis of long-term hydrological trends and storm and storm hydrographs on the Finke and Hugh Rivers has been undertaken (BECA 2016). Whilst not site specific, the data provides a reasonable estimate of local climatic and rainfall data as well as the behaviour of water within the sub-catchments referenced above. The results of this work, have been used to develop an estimate of flood inundation within the Proposal area.

9.3.9 Geomorphology

A detailed geomorphology baseline assessment is contained within the Beca (2016) report in Appendix R. The key objectives of this geomorphology assessment were identified as follows:

- Characterise geomorphological baseline conditions in existing channels.
- Sample and test sediments for physical characteristics.
- Identify key habitat within the existing channels.

Six sites were selected for the geomorphology study based on the following criteria:

- Major watercourses.
- Representative watercourses for the Proposal in terms of type, catchment area and geographical spread.
- Within the likely sphere of influence of the Proposal.

- Sites with existing data collection as part of the Proposal.

As a result, sites CS005013, CS005021, CS005041, GEOM1 (Finke River), GEOM2 (Railway Crossing Creek) and GEOM3 (Hugh River crossing near Titjikala) were nominated. The results from both the desktop and site work fluvial geomorphology baseline study are shown in Figure 9-2 and presented below.

Stream order

The Strahler stream classification system is a method of classifying waterways according to the number of tributaries associated with each waterway (Strahler 1957). Numbering begins at the top of a catchment where the headwaters of the system start. As the stream order increases the contributing catchment area and channel size also increase. Small tributaries at the top of the catchment are assigned as a first order streams. Where two first order streams join, the waterway downstream of the junction is referred to as a second order stream. Higher order streams are found in the lower parts of the catchment.

All drainage lines within the area surrounding the Chandler Facility are 1st order, with the exception of Halfway Creek (downstream from Halfway Dam), Chambers Pillar Road Creek downstream from Robinson Dam, Charlotte Range Creek downstream from bore # 14288 and Apirnta Creek downstream from the railway crossing which are all second order. The major of watercourses in the study area, Finke and Hugh Rivers are greater than stream 5 order.

Long profile analysis

Gradient have been assessed to assist in the characterisation of major courses. No long profile analysis was possible for CS005041, Finke River, Hugh River and Railway Crossing Creek sites because contours were too coarse (50 metres). The long profiles for sites CS005013, CS005021 and CS005031 (contour resolution 2 metres) have been plotted for comparison in Figure 9-16.

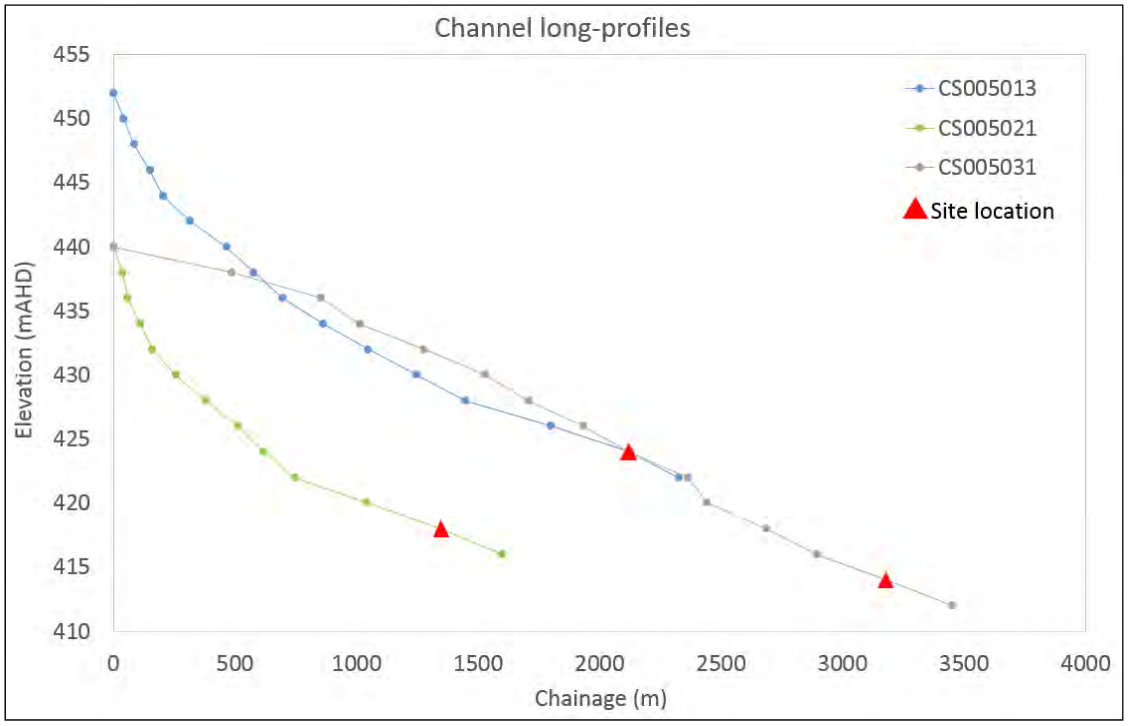


Figure 9-16 Long profiles of study channels

Typically, erosion zones are likely to occur on steep / vertical down gradient sections and deposition zones would occur on flat reaches with little to no downfall. As such, it is clear from these long profiles that all sites would be characterised as depositional environments, although sites CS005013 and CS005021 do have significant up-gradient erosion potential indicated by high gradients in the headwaters.

Channel planform

Sinuosity has been assessed to assist in the characterisation of major courses. The sinuosity derivations have been provided below in Table 9-11.

Table 9-11 Sinuosity estimates for study reaches

Study reach	Blue line network length (m)	Straight line length (m)	Sinuosity	Description
CS005013	2,125	1,987	1.1	Low
CS005021	1,349	1,266	1.1	Low
CS005041	1,800	1,800	1.1	Low
GEOM01	96,256	42,172	2.3	Meandering
GEOM02	9,860	8,630	1.1	Low
GEOM03	58,805	40,815	1.4	Meandering

Sinuosity is considered low if the degree of calculated sinuosity is between 1.06 and 1.30 and meandering between 1.31 and 3.0 (Brierly and Fryirs 2005). Open drainage lines within the alluvial floodplain show no defined or a discontinuous channel and low sinuosity. Finke River and Hugh River are considered meandering (high sinuosity).

As the majority of the study reaches are headwaters with low sinuosity, characterisation of meander bed characteristics (e.g. wavelength, amplitude, bend radius) was not relevant to the impact assessment.

Channel cross-sections

Typical cross-sections for the Hugh River and Railway Crossing Creek are provided in Figure 9-17. Environmental traverses for the existing Chandler Facility hydrographic stations have not been provided at the time of writing this report so cross-sections for these four sites (i.e. CS005013, CS005021, CS005031, CS005041) are not included. The Finke River was flowing at the time of the site visit so a cross-sectional survey was not possible due to health and safety reasons.

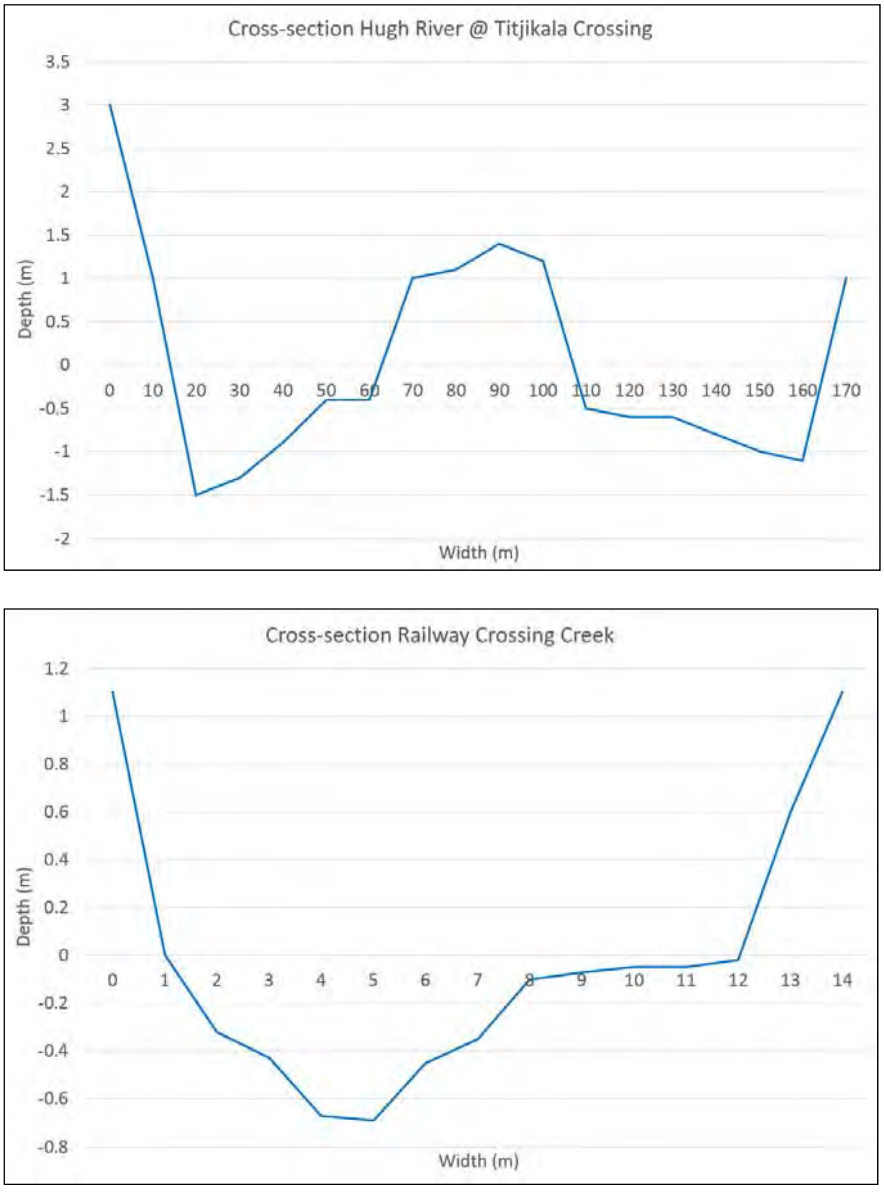


Figure 9-17: Typical cross sections for (a) Hugh River (b) Railway Crossing Creek

Sediment characteristics and transport

Variation in particle size for the five sampling sites are shown in Figure 9-18. Notable trends in particle size distribution were:

- GEOM02 and GEOM03 had largest particle size with a larger proportion of coarse sands and gravels than other sites. It is postulated that these two sites have higher flow velocities.
- CS005021 and CS005041 had the smallest particle size with the largest proportion of coarse silt and clay than other sites. It is postulated that these two sites have the lowest flow velocities as gradient in the flood out zones are lower and lack of channel form means flow is not constricted.
- No sites contained fine silts.
- Median particle size for CS005013, GEOM02 and GEOM03 was in the 0.15-0.3 mm fine sand range.
- Median particle size for CS005021 and CS005041 was in the 0.075 – 0.15 mm very fine sand range.

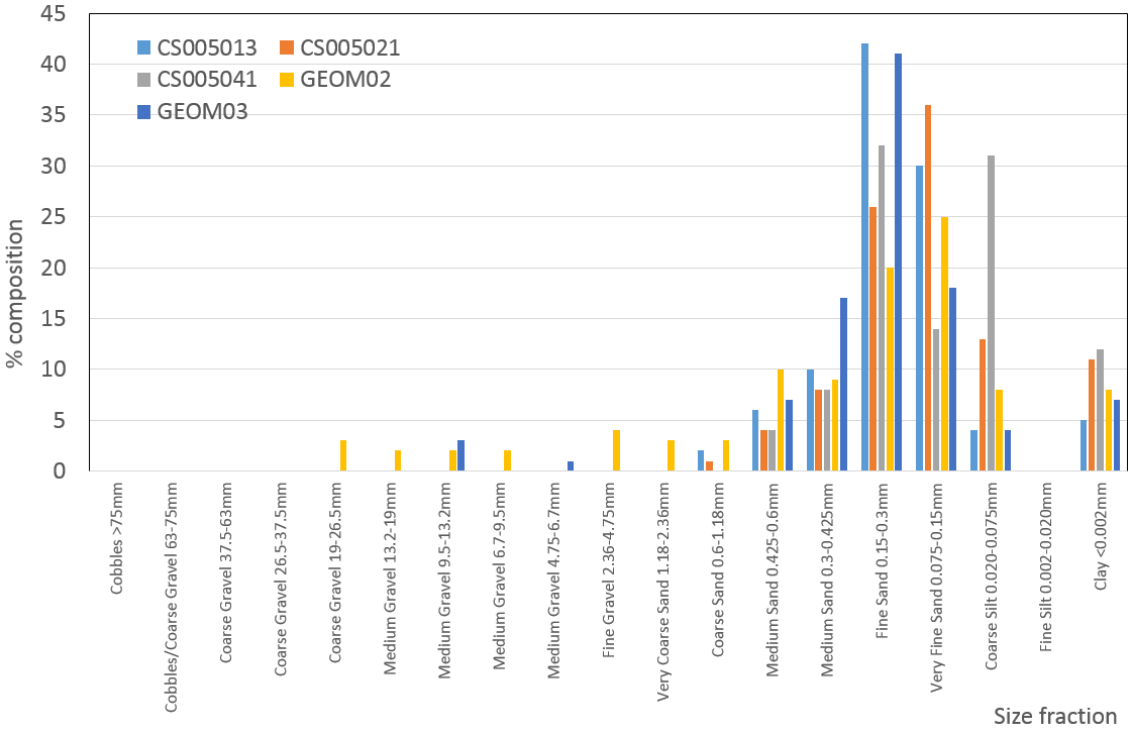


Figure 9-18: Particle size distributions

Sediment provenance and loads

At the time of writing this report, no flow nor suspended sediment concentration data has been provided for the nine storm samples collected from the surface water monitoring program. As such, it is not possible to estimate sediment loads transported down-gradient during storm events. Furthermore, it is not possible to establish the relationship between sediment size and the velocity

regime causing erosion, transportation and deposition of channel material using a Hjulström curve as velocities have not been measured during storm events.

What can be concluded from particle size data are the theoretical thresholds for motion of sediments of known sizing. As such, median sediment particle size determined by geomorphology field investigations have been compared in Table 9-12 to the known velocities (cm/s) controlling movement or deposition of sediments in the study channels.

Table 9-12: Thresholds for movement of study channel sediments

Study reach	Median particle size (mm)	Motion threshold (cm/s)		
		Deposition	Transport	Erosion
CS005013	0.3	<2	2	10
CS005021	0.15	<1	1	12
CS005031	0.075	<0.8	0.8	15
CS005041	0.15	<1	1	12
GEOM01	0.3	<2	2	10
GEOM02	0.3	<2	2	10
GEOM03	0.15	<1	1	12

It is evident that it would be most difficult to deposit and transport sediments at CS005013 and GEOM03 due to the calibre of sediments found here. However, it is easiest to erode sediments at these two sites, conversely, because of a lack of silt and clay content which performs a cohesive function against flow shear stress.

It is hypothesised that sediment availability in the study channels is controlled by a combination of rainfall intensity, land cover and grazing pressure. Sediment transport is controlled by channel gradient and particle sizing.

Geomorphological classification of watercourses

A description of the River Styles™ types for each watercourse are listed below:

- CS0013 is a low-moderate sinuosity sand bed discontinuous channels. They feature chain of ponds with sand sheets and lateral bar features.
- CS005021 and CS005041 are both flood outs.
- GEOM01 is a fine-grained anabranching channel in an alluvial valley setting.
- GEOM03 is a coarse-grained anabranching channel in an alluvial valley setting.

The implications of these channel types for surface water geomorphological functioning are that the discontinuous channel are sediment supply systems in headwater catchments with rapid response to rainfall events.

The alluvial valley setting channel at GEOM01 and GEOM03 would act as a sink for sediments, with gradual deposition and channel accretion over time. However, large storm events would move this material further downstream in ‘slugs’.

The Finke and Hugh Rivers are anabranching[27]. Characteristics of an anabranching river are flood dominated flows and erosion resistant banks (Nanson & Knighton 1996). Some systems characterised by mechanisms to block or constrict channels trigger avulsion (Nanson & Knighton 1996).

For the Finke and Hugh Rivers the flow can diverge for a large distance before re-joining the main channel. Anabranching river channels are active and are thought to be more efficient at moving water and sediment than a single channel at the same flow discharge (Monroe 2008). They are expected to have a lower velocity compared to single channels. Therefore, the Finke and Hugh Rivers have more periods of low flows and infrequent periods of high flows as a result of flood events.

Instream habitat

Part of the function of a geomorphological assessment is to identify sensitive habitat that might require special protection from impact.

No refuge pools were observed during the site walkover and it is clear that waterbodies within the mining lease area are ephemeral, rarely flowing except under extreme wet conditions. Instream habitat is not diverse, with a blanket of coarse sand observed at CS005013 thought to be due to high bedload transport during flow events.

Flood out sites have compact sand beds, thought to be a result of deposition of fine sands during sheet flow and gradual evaporation / percolation of waters forming a pan. However, vegetation assemblages associated with the channels / flood-outs are apparent. Low salt tolerant species were observed along the channels, indicating a source of fresh water other than groundwater springs.

The Finke River and Hugh River, however, have rich in-channel habitat diversity (see Plate 9-6). The low-moderate sinuosity sand bed stretches would act as conveyance stretches, storing sediments in-between events and supplying them to downstream reaches during high flow conditions. They would probably not provide material in-situ as the channels here are relatively stable. Conversely, the meander bends would provide new material to the channel during high flow events, due to erosion on the apex of the curve facing highest water velocities.

The secondary cut-off channels on both the Finke and Hugh Rivers perform an important function during high flow events and subsequent receding flows, providing additional storage capacity to reduce the likelihood of channel overtopping and acting as a fine sediment sink, respectively.

[27] *Sections of the river channel split from the main channel and re-join further downstream.*



Plate 9-6 Finke River in-stream habitat and pool areas laden with fine alluvial sediment deposition

The anabranching channels provide a complex geomorphological function, maximising bed sediment transport (work per unit area of the bed) under conditions where there is little opportunity to increase gradient. These features were located immediately downstream from the apex of meander bends, showing that the bends are a source of new material in the channel and that lower energy conditions downstream allowed subsequent deposition during flow recession forming the separating ridges. Major floods in the Finke and Hugh Rivers would form a laterally active short-lived anabranch.

Large woody debris was observed in the Finke and Hugh River channels, partly sourced from overhanging vegetation but also from further upstream. Bed or bank stabilisation by woody debris has been postulated in previous studies (Erskine *et al*. 2001).

In the Finke and Hugh Rivers, formation of semi-permanent log steps did dissipate energy, store bed load. However, due to the non-cohesive nature of the bed sediment and the large velocities predicted during high flow events, the presence of large woody debris only stabilised bed profiles on a temporary basis. In fact, scour and increased velocities (as reflected in increased particle size) was noted in the lee of logs and branches deposited within the channel due to creation of roughness.

Large woody debris was also observed in Halfway Creek and Mary's Creek predominantly sourced from in-stream debris (see **Plate 9-7**). The presence of large woody debris in this location appears to have stabilised bed profiles, at least on temporary basis. Evidence of historic high velocity flow events within Halfway Creek were seen upstream of Halfway Dam (see Plate 9-8).



Plate 9-7 Evidence of large woody debris within Halfway Creek

9.3.10 Flooding

A method has been developed to estimate areas of standing water from data recorded by the Moderate Resolution Imaging Spectroradiometer, an optical instrument on board the Terra and Aqua orbiting satellites (Guerschman *et al*. 2011).

Figure 9-16 plots an average of annual maximum inundation plots from between 2000 and 2015, developed using this method. Brighter colours indicate a greater frequency of water observations. Whilst being of coarse resolution (cells of approximately 475 metres by 475 metres), this data identifies a number of endorheic basins where water has ponded for a period of time. Within the Proposal area few distinct patterns can be seen, indicating both limited and spatially-varied ponding.

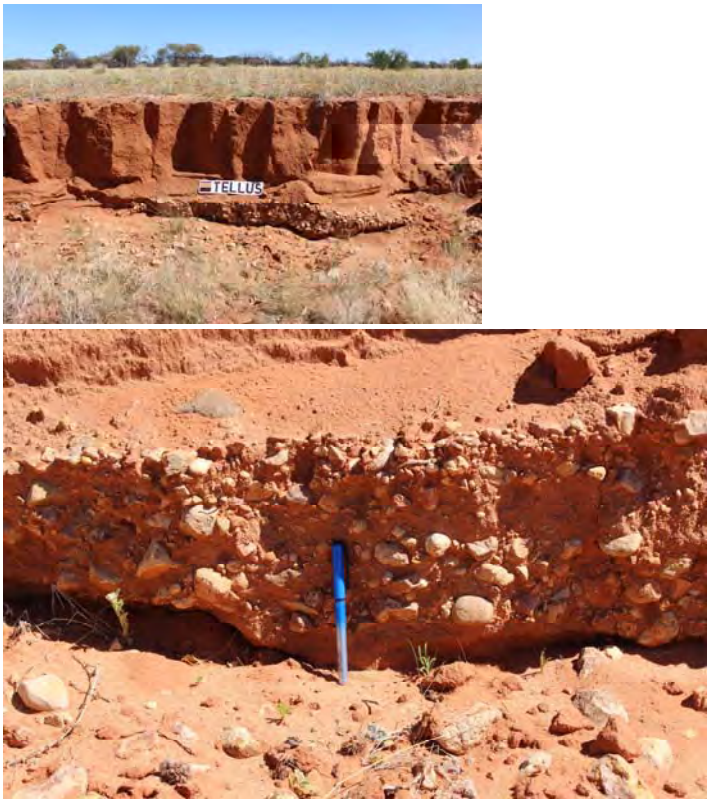


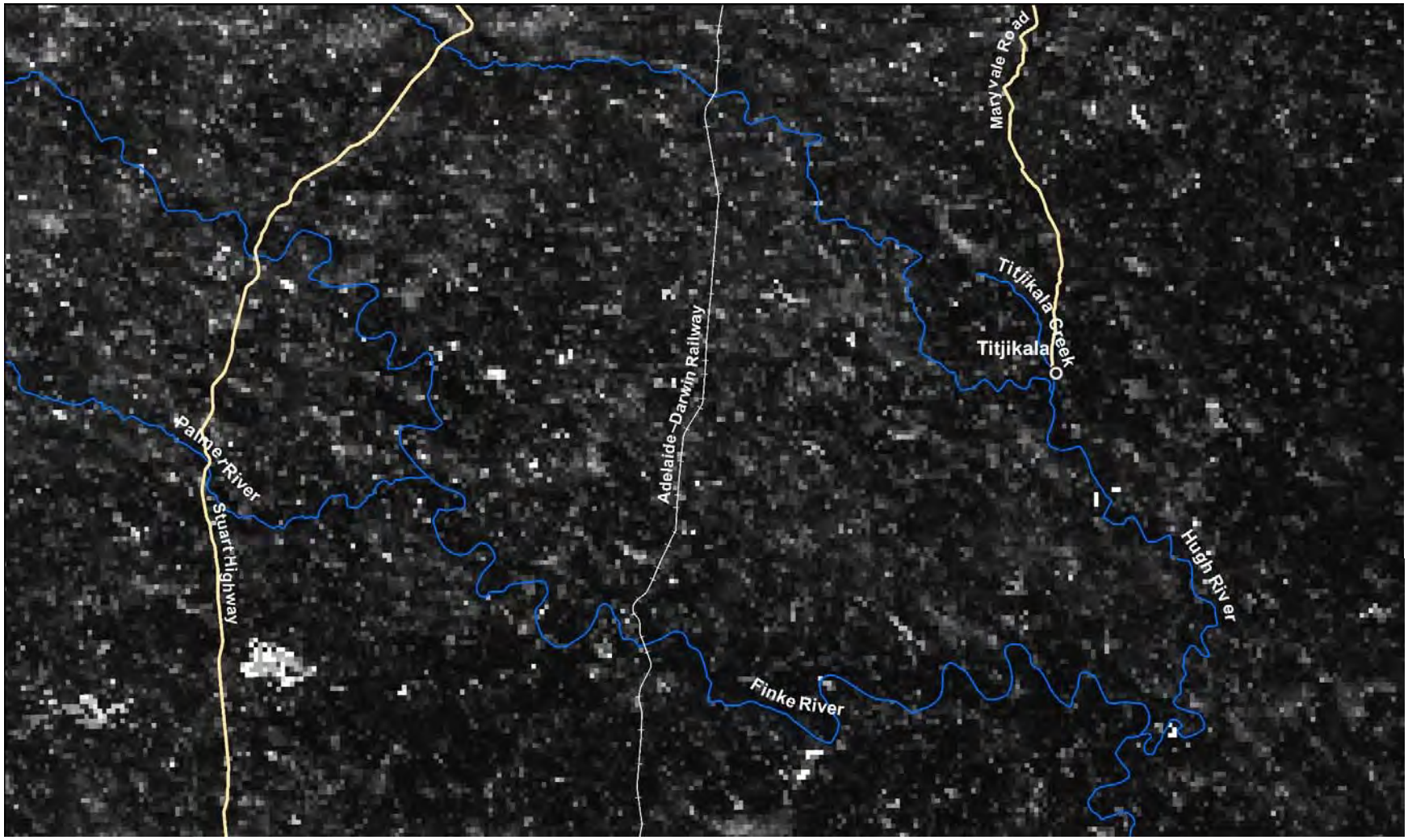
Plate 9-8 Evidence of historic high velocity flow events in Halfway Creek

Geoscience Australia (2016) developed a similar dataset, at a higher resolution (25 metres), a lower frequency but over a longer period. This data, derived from the Landsat 5 and Landsat 7 satellite imagery archive and known as *Water Observations from Space* (WOfS), presents the percentage of (good-quality) observations on which water was detected between 1987 and 2016. It is aimed to better understand where water is usually present and where it is seldom observed. plots the WOfS dataset for the CSMP area.

The Finke River is clearly distinguished, with water detected between 2 % and 50 % of observations along its length. Higher-observation areas correspond roughly to refuge pools and waterholes. The Hugh River is narrower in width, and so harder to identify in the WOfS data. Water is detected between 1 and 5 % in most sections, with occasional segments registering water in 20 % of observations. This confirms both flow record interrogation and anecdotal observations that the Hugh River is dry for longer periods of time than the Finke. Water flowing in the Palmer River is generally below the spatial and / or temporal resolution of this dataset.

Scattered ponds in the order of 100 metres to 500 metres in diameter can be seen across Figure 9- 19, particularly within the sand dune to the west of the Proposal area and the headwaters of Chambers Pillar Road Creek. The only ponding detected within the proposed Chandler Facility Mine Infrastructure Area is that of Halfway Dam (see Figure 9-20).

Figure 9-19 Average of annual maximum inundation from between 2000 and 2015



Source : ANU, 2016 - Brighter colours indicate a greater frequency of water observations.

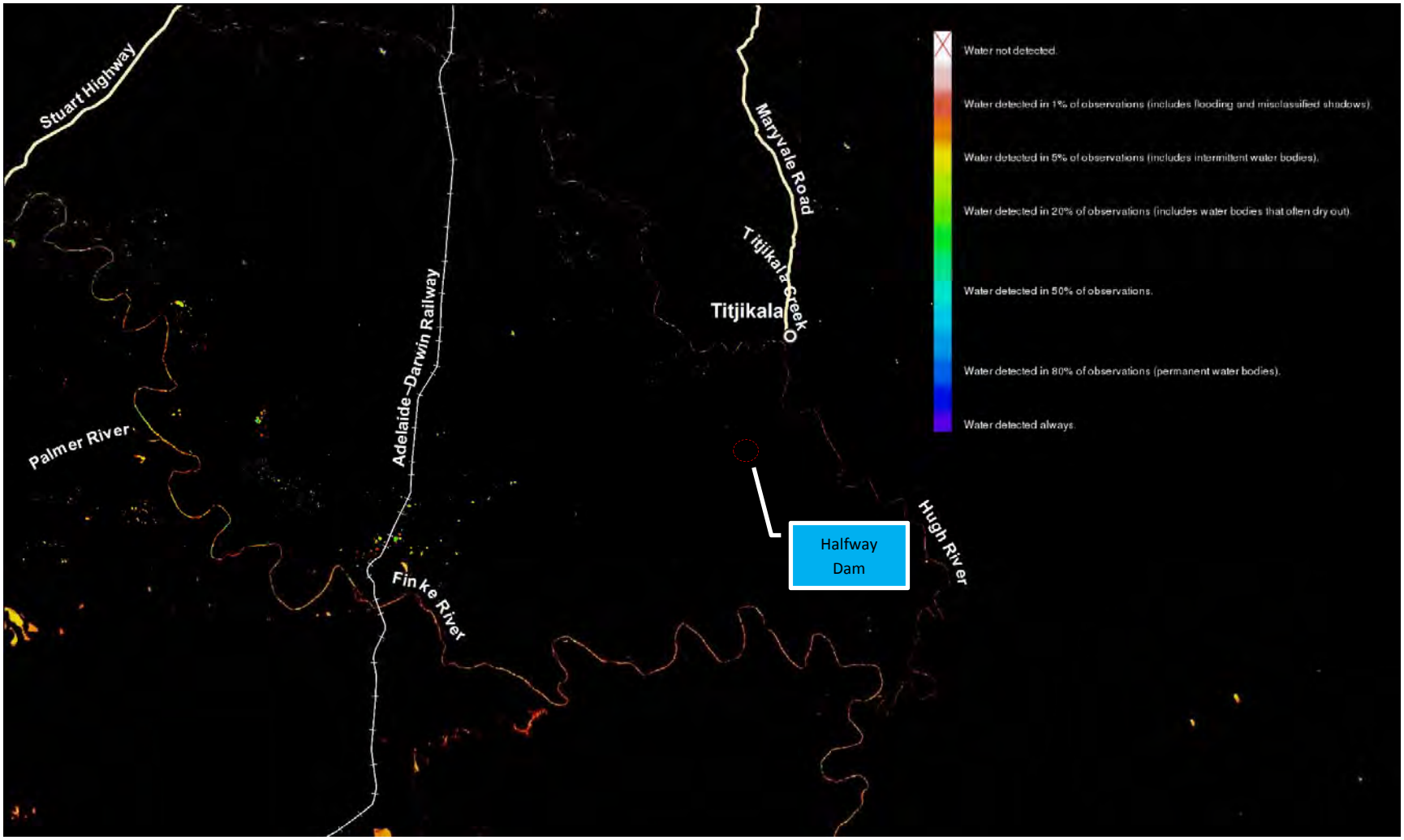


Figure 9-20 Water detected between 1987 and 2016 - image taken from GA (2016) Water Observations from Space dataset

Flood hydrographs have been defined for the catchments draining to the Proposal infrastructure (mine site, haul road and railhead) using the Australian Rainfall and Runoff (ARR87) guide to flood estimation and HEC-HMS hydrological modelling software. The resulting flood estimates have been verified with reference to the flood frequency of the major rivers.

The ARR87 approach requires:

- Catchment areas, lengths and slopes to be defined.
- Design rainfall.
- Storm depth.
- Aerial reduction.
- Profile.
- Losses.
- Method of the transforming effective rainfall into a flow hydrograph. This includes calculating the Time of Concentration (Tc)

Estimated peak flood flow rates from a generalised extreme value distribution fit of this data are given in Table 9-13 for the Hugh and Finke Rivers.

Table 9-13 Estimated flood flow rates at the Hugh and Finke Rivers

Return period (years)	Hugh River (m^3/s)	Finke River (m^3/s)
500	8,140	-
100	2,964	2,039
50	1,894	1,430
10	616	565
5	346	340

9.4 Assessment of risk during construction

Potential impacts on surface water environments within the Proposal area were identified in Section 0. This section presents the potential impacts (both direct and indirect) on surface water during construction of the Proposal. Mitigation measures to avoid or reduce these impacts are discussed in Section 9.7.

9.4.1 Direct impacts

Direct impacts on surface water during construction of the Proposal include erosion, flooding and changes to existing site surface water flows. These impacts are discussed below.

Soil erosion in disturbed areas resulting in increased sedimentation

In a disturbed environment, even a small amount of water can cause erosion. Whenever a raindrop hits bare soil it disturbs the soil aggregates and splashes soil particles into the air. Once the soil is

disrupted it is easily eroded. More intense rainfall causes an increase in disruption to bare soil (DLRM, 2013b).

Soil erosion is one form of soil degradation. The erosion of soil is a naturally occurring process on all land. The agents of soil erosion are water and wind, each contributing a significant amount of soil loss each year. Soil erosion may be a slow process that continues relatively unnoticed, or it may occur very quickly causing serious loss of topsoil. Accelerated erosion causes both "on-site" and "off-site" problems. The erodibility of a soil also depends on inherent soil characteristics, such as structural stability and infiltration rate (Dilshad 2007). The greater the structural stability of a soil, the greater is its resistance to being broken down by raindrop splash and overland flow. In addition, if it has a high infiltration rate, more water can percolate in the soil per unit time, which minimises shallow surface flow.

The Proposal includes three sites (Apirnta Facility, Chandler Facility and Road Infrastructure) with their site characteristics summarised in Table 9-14. For the purposes of this Erosion and Sediment Control Assessment, the Chandler Facility refers to overground features only. A more detailed description of the three sites can be found in Chapter 1 (Introduction).

Most runoff on the Apirnta Facility and Haulage Road sites are expected to occur as sheet flow. A film of water spreads across the soil surface, having low volume, velocity and energy. In undisturbed areas, this has low potential for erosion. However, if runoff is diverted or concentrated in sheet flow areas (e.g. along the eastern side of the railway track on the Apirnta Facility site or in channels crossing the Haulage road route), flow velocity and volume is increased. This leads to a higher risk of erosion.

At the Chandler Facility, degree of slope up-gradient would determine the amount of runoff energy on the site itself. The Maryvale Hills situated directly to the east are sufficiently sloping to create very rapid water flow. Rapid water flow can be very erosive and the length of slope would determine the speed and energy available to cause erosion. As such, the two drainage lines of most concern within the Chandler Facility footprint are the Mary's Creek and Halfway Creek.

Both gullies are > 2 kilometres in length, falling from 480 to 424 m AHD. Dingo, Oak, Ridey and Snake Gully's' by comparison are 0.5 kilometres long, falling from 450 AHD to 424 m AHD. Sheet flow and concentrated flow at the Chandler Facility site eventually accumulates in low lying drainage lines or depression areas, flowing towards the flood out area downstream. This runoff would therefore impact down- slope habitat.



Table 9-14 Summary of site characteristics

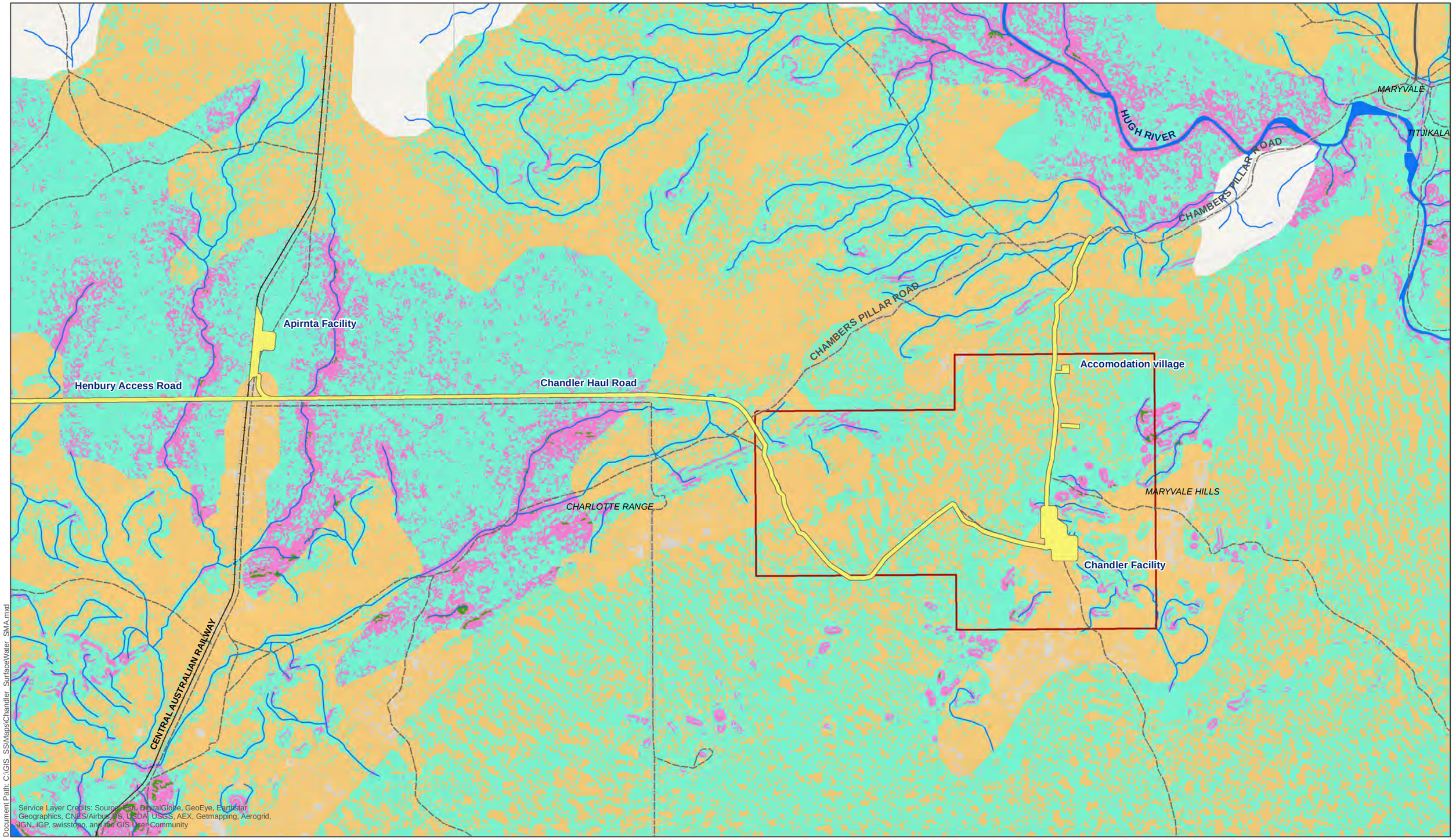
Site name	Location	Site size	Average site slope	Upslope runoff	Soil type	Watercourse name
Apirnta Facility	Maryvale pastoral lease	0.40 km^2	0.3%	4 km^2 with a 100 year ARI flow of 13 m^3/s	Aeolian sand (soil type Q_s)	Apirnta Creek
Chandler Facility	Maryvale pastoral lease	0.86 km^2	1.25%	4.1 km^2	Aeolian sand (soil type Q_s)	• Dingo Gully • Halfway Creek • Mary's Creek • Mulga Creek • Oak Gully • Ridey Gully • Roo Gully • Snake Gully
Road infrastructure	Maryvale pastoral lease	0.27 km^2	Not applicable	1.6 to 1,800 km^2 with a 100 year ARI flow of 5.8 to 2,704 m^3/s	Aeolian sand (soil type Q_s) 57% alluvial gravel, sand and silt (soil type Q_a) 42% conglomerate (soil type Q_c) 1%	Multiple drainage channels including: • Apirnta Creek • Chambers Creek • Charlotte Creek • Finke River • Hugh River

To assess erosion potential for the entire Study Area, a bespoke Erosion Hotspot Model of the Study Area was created (adapted from Evans *et al*. 2006). More details on how this model were generated can be found in Appendix R (Erosion and Sedimentation Assessment). A raster layer map was produced in GIS platform to display these erosion risk classifications visually with different colours representing different erosion potentials within the Study Area (see Figure 9-21).

The mapping shows that in general the east of the Study Area incorporating the Chandler Facility to the west of Maryvale Hills, Halfway Creek catchment, Chambers Pillar Road Creek have negligible, slight or low erosion potential.

The west segment of the study area incorporating Apirnta Creek, Charlotte Creek and the rail line have low or intermediate erosion potential. Areas of high erosion potential are generally grouped along creek / river lines reflecting hydrological connectivity and increased risk of sedimentation issues.

Very high erosion potential cells were in the upper catchments of these drainage lines, demonstrating the influence of lower ground cover and steeper slopes as well as hydrological connectivity.



Document Path: C:\GIS_SSMaps\Chandler_SurfaceWater_SMA.mxd

N

1.5 0.75 0 1.5 Kilometers

Coordinate System:
GDA 1994 MGA Zone 53

Legend

- Proposed development footprint
- Watercourse
- Mining Lease Area

Erosion risk value

- Negligible
- Slight
- Low
- Intermediate
- High
- Very high

Figure 9-21
Erosion potential hotspot map

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; USGS, SRTM elevation, 2000; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller

Vegetation clearance

Clearing and grubbing of the Chandler Facility, Apirnta Facility and Haulage Roads would be necessary to carry out further site preparation activities as described in the Proposal Description of the EIS (Chapter 3).

Under the Northern Territory Planning Scheme, native vegetation is defined as *'terrestrial and inter-tidal flora indigenous to the Northern Territory, including grasses, shrubs and mangroves'* (DLRM, 2013a). This means that clearing of any native vegetation for the Proposal requires consent, including vegetation cleared prior to the introduction of the native vegetation clearing controls. There are some general exceptions, which might apply to specific areas of the Proposal including clearing for:

- Fire breaks 5 metres wide for properties <8 hectares, or 10 metres wide for properties > 8 ha.
- Internal fence lines (up to 10 metres wide) only on properties > 8 hectares.
- Other exceptions as listed in the Northern Territory Planning Scheme.

These activities give rise to the following potential adverse impacts:

- Removal of filtering function for sediment and other pollutants from surface runoff by vegetation systems leading to a deterioration in water quality and associated loss of aquatic habitat.
- Decrease in shade and protection from wind and water erosion afforded by plants.
- Reduced infiltration and rise in salt water level.
- Decreased habitat quality surrounding the site, drainage lines and other sensitive areas.
- Increase in the speed of water runoff discharging creeks, exacerbating downstream flooding.
- Increase in chemical spray drift, noise and dust.

The potential impacts of vegetation clearance thus include the unnecessary removal of valuable native vegetation with associated habitat loss and fragmentation. Removal of the filtering function of vegetation surrounding watercourses leading to increased sediment input into creeks during rainfall events is another potential impact. Exposure of topsoil to rainfall leading to exacerbated erosion impacts would require pre and post construction mitigation. The site-specific impacts related to vegetation clearance are covered in Chapter 7 (Biodiversity) and in the Sediment and Erosion Plan (Appendix L).

Altered hydrology

The direct potential impacts of the Proposal on the hydrological regime of the receiving environment surrounding the mine infrastructure area is discussed below.

Chandler Facility

The Chandler Facility (mine infrastructure area) is about 3.5 km^2, with an upstream catchment area of 4.1 km^2. The village area is 3 kilometres north of the mine site, which is an area of about 0.35 km^2.

Under current proposals the remainder of the 100 km^2 mine lease site would not be developed. The majority of the lease area (including the mine site and accommodation village) lies within an 84 km^2 catchment with topographic gradient orientated north-east through the Charlotte Ranges towards the Hugh River and Titjikala, as shown in Figure 9-22.

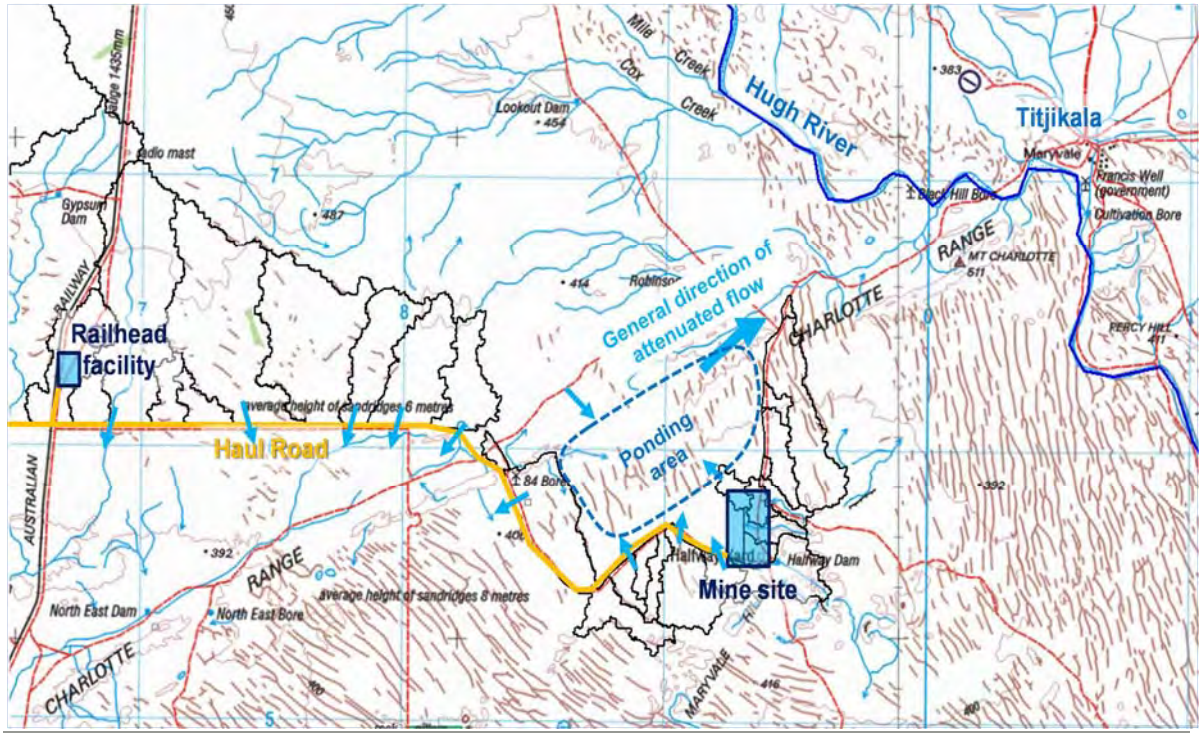


Figure 9-22 Topography and drainage lines

There are no signs that the drainage pathway from the MIA to the Hugh River is a permanent watercourse, and the Hugh River runs for less than 10% of the time. Water flowing through or from the mine site drains towards a flat washout area prior to passing towards the Charlotte Ranges. The detailed DEM only covers part of this washout area, but it is anticipated that the majority of the runoff would pond in this area, with significant to losses to evaporation and infiltration resulting in limited runoff reaching the Hugh River in all but the largest flood events. A conceptual drainage model for this area is detailed in the Surface Water Baseline Report (Beca 2016).

The 84 km^2 catchment draining the mine lease area towards the Charlotte Range would generate about 5.5 million m^3 of runoff in the 100-year ARI 9-hour storm. This represents a runoff coefficient of about 54 %. If 3.5 km^2 of the mine site were to be 100 % impervious, then this would contribute an additional 190,000 cubic metres of runoff to the catchment, which represents an increase of 3.5 %. The catchment topographical gradient lies towards the washout area before heading north-east towards the Hugh River and Titjikala. The washout area is about 12 km^2 (though difficult to define without detailed DEM) and would attenuate the flood.

The additional runoff from the mine site would represent an increase in water depth on the washout area of about 15 mm, if the area were totally ponded. However, while ponding in the washout area, floodwater would infiltrate into the ground and be subject to very high evaporation rates over a large area such that the effect of any additional runoff would be reduced further.

On this basis and as the mine site, accommodation village, and catchments upstream of the mine only represent about 10 % of the catchment draining through the Charlotte Ranges, it is not anticipated that the change in hydrological regime due to the Chandler Facility would have a noticeable effect on the Hugh River near Titjikala.

At the south-eastern boundary of the mine site lies Halfway Dam, which captures runoff from a 3.5 km^2 catchment. The current plan is to relocate Halfway Dam further down the creek line and utilise its current site as the salt stockpile (Tellus 2016). Therefore, further investigation during detailed is required to:

- Find a suitable location for a new dam;
- Assess the effect of any mine activity in the catchment upstream on flow yield / reliability; and
- Inform the dam location, intake structure (visible on Google Earth), and dam capacity.

Chandler Haul Road and Apirnta Facility

Upslope stormwater would flow through the Apirnta Facility, Chandler Facility and Haulage Road sites. Free passage of upslope stormwater would lead to additional water volume to manage. Water might become ponded on the site or flood infrastructure causing access issues or damage to critical equipment. It would also mix with dirty / contaminated water and thus necessitate additional treatment treatments. The additional water could cause structural damage to soils, leading to increased erosion.

The drainage lines crossing the haul road and intercepted by the Apirnta railhead facility generally flow in a southerly direction towards a drainage line running south-westerly along the northern flank of the Charlotte Range, and hence to the Finke River. Between the Chandler Facility and the railhead, the river is about 19 km from south of the Chandler Haul Road.

The only infrastructure of note downstream of the Chandler Haul Road are the rail crossing of the Charlotte Creek drainage line along the northern flank of the Charlotte Range and North-East Dam shown on the surface water bodies map in the Baseline report (Beca 2016).

Though the upgraded Chandler Haul Road would be less pervious than the existing track, the area would be insignificant when compared to areas of contributing catchments. As such, it is not anticipated that the proposed Chandler Haul Road would increase the peak flood flow or volume at the rail crossing or dam. If the Chandler Haul Road is raised, there is the potential for storm runoff to be intercepted and ponded upstream of the road. If the effect of the road is to be neutral, then measures should be taken to minimise upstream ponding.

The Apirnta Facility occupies a site of about 0.4 km^2, in a catchment of about 8 km^2 draining south towards the proposed Chandler Haul Road. The flood modelling of this catchment shows a runoff coefficient of 72 % in the 100-year ARI 9-hour storm, generating 700,000 m^3 of runoff. Were the 0.4 km^2 of the Apirnta Facility to be 100% impervious, then runoff would increase by 13,000 m^3 or 1.9 %. It is assumed that site runoff would be collected for treatment, and so it is not anticipated that there would be an increase in peak flow 4 kilometres downstream at the haul road.

9.4.2 Indirect impacts

Chandler Facility

Storm profiles

The critical storm durations for the identified catchments were assessed to determine the potential impacts associated with flood durations at the Chandler Facility, Apirnta Facility, Chandler Haul Road and Henbury Access Road.

Depending on the catchment size and shape, they were defined by the calculation of the catchment Time of Concentration as being from 1.5 to 24 hours. The storm rainfall depths for these critical storm durations were distributed using the storm profiles for Zone 5 in ARR87 Table 3.2. Examples of the 1.5, 6, and 24 hour rainfall profiles for the 100-year ARI storm events are provided in Figure 9-23, Figure 9-24 and Figure 9-25.

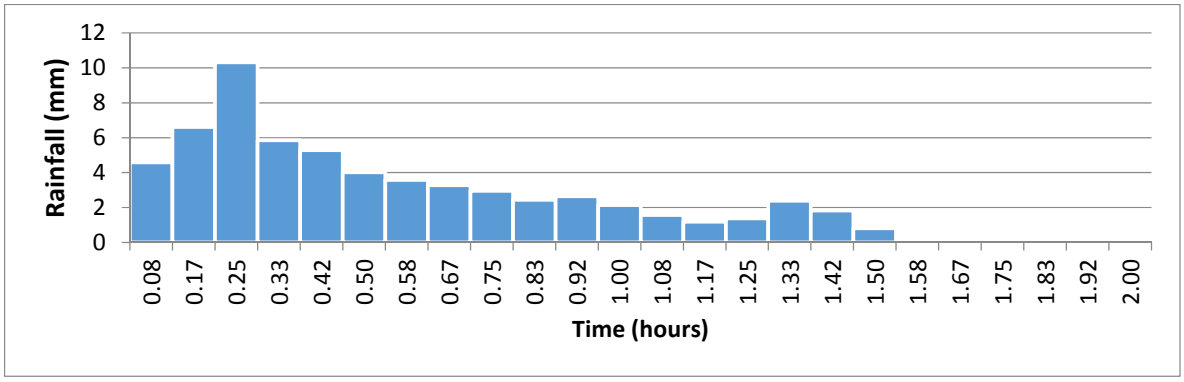


Figure 9-23 1.5 hour storm profile for 100-year ARI rainfall depth of 62.9 mm

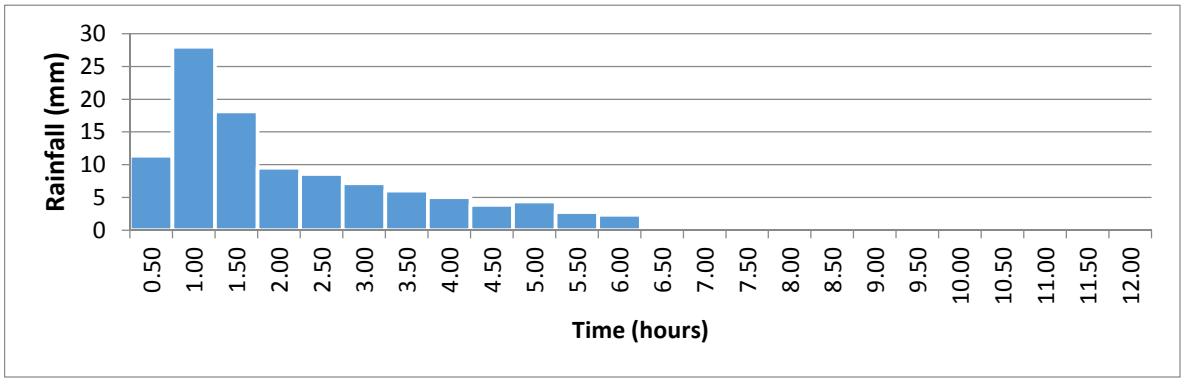


Figure 9-24 6 hour storm profile for 100-year ARI rainfall depth of 107.4 mm

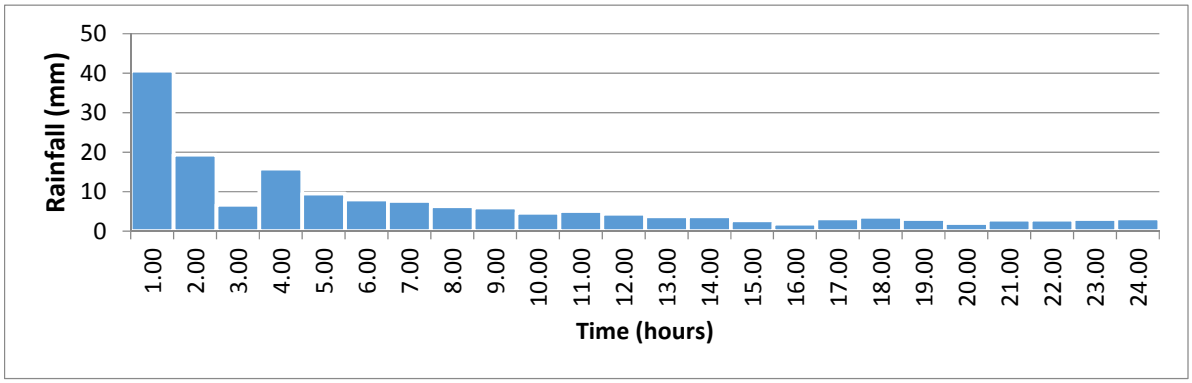


Figure 9-25 24 hour storm profile for 100-year ARI rainfall depth of 170.2 mm

However, subsequent modelling indicated that the losses applied to the rainfall resulted in little, or no, effective rainfall during short duration (< 3 hours) rainfall events, and that the maximum peak flows for the majority of catchments affecting the mine infrastructure were generated by storms of 6 to 12 hours duration.

For the 2-year ARI event, the 12 hour storm generated the highest peak flows. For the 10-year ARI event, there was little difference in peak flows generated by the 6, 9 or 12 hour storms. However, for the 100-year ARI event, the 6 and 9 hour storms generated the highest peak flows. The general relationship of the critical storm duration moving toward the catchment Time of Concentration as the magnitude of the event increases is expected, as the ratio of rainfall losses to total rainfall reduces.

The chance of that size of storm falling across the whole catchment reduces with catchment size. Therefore, a factor was applied to the rainfall depth. The factor varies according to catchment size and the storm duration, as shown in Figure 9-26 which was used for determining the factors for the Proposal's infrastructure catchments.

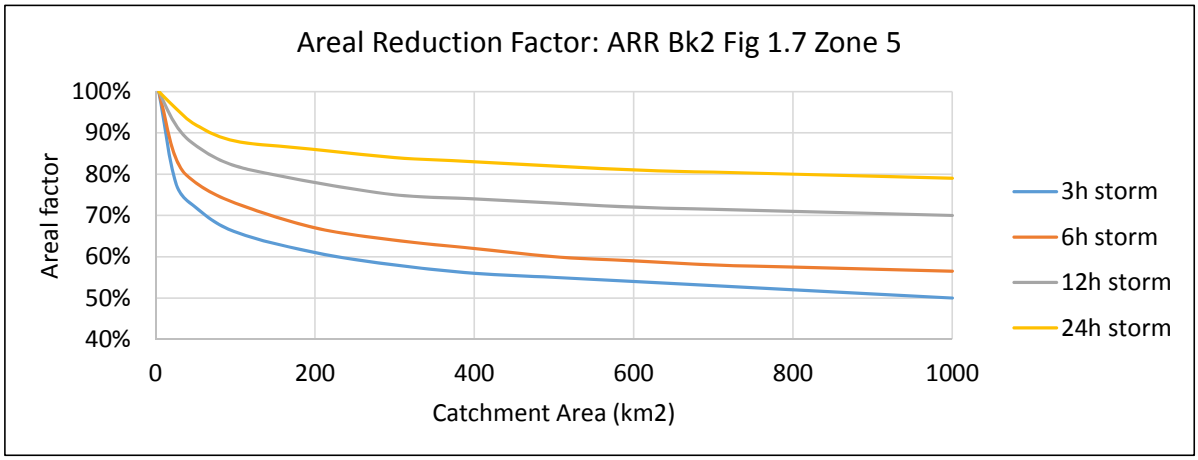


Figure 9-26 Rainfall areal reduction factor

Not all of the rainfall that falls on the catchment would contribute to storm runoff. Depending on antecedent conditions, vegetation and other factors, some of the rain is intercepted by vegetation, some lost to infiltration into the ground, while more may be held in shallow depressions / clay plans.

ARR87 suggests that rainfall losses should be accounted for by applying an Initial Loss (Ia) to the rainfall and then an Ongoing Loss (OL) for the duration of the storm. For 'Central Australia' parts of the Northern Territory, Table 3.8 of ARR87 Book 2 directs the user to the losses for 'Arid Zone' parts of South Australia, which are given in Table 3.4 of ARR87 Book 2. Two combinations of initial and ongoing losses are provided; Initial Loss of 15 mm or 40 mm, and Ongoing Loss of 4 mm/h or 1- 3 mm/h. Using an Initial Loss of 40 mm, rainfall depths would result in no runoff for the majority of design events of 5 years ARI or less. While selecting a higher ongoing loss is expected to result in no effective rainfall from much of the longer-duration storm profiles.

Flow results

Using the method for rainfall flow transformation in Section 9.2.6, a calculation was made to model and show the relationship between peak flows across the catchments affected by the Proposal which range from 6 km^2 to 246 km^2 (Figure 9-27). For the 10-year and 100-year ARI events there are good relationships that can be described by power equations. However, the relationship for the 2-year ARI event is less clear, with peak flows appearing to reduce once the catchment size is greater than about 100 km^2. This could reflect the longer times of concentration for these larger catchments, and hence, the greater relative effect of ongoing rainfall losses in reducing the effective rainfall.

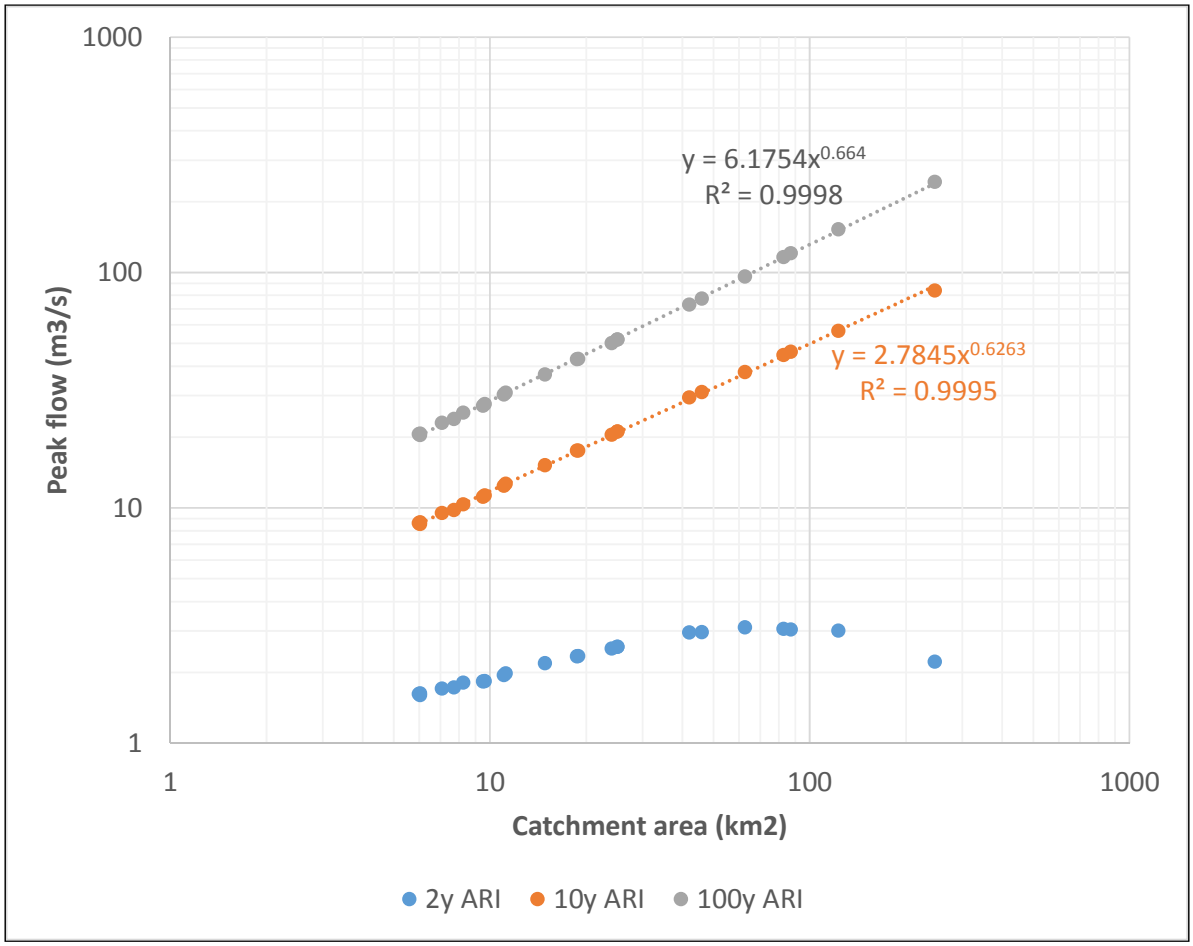


Figure 9-27 Catchment area – peak flow relationship

Figure 9-28 shows the peak flows per km^2 of catchment. As with Figure 9-27, the 10-year and 100- year ARI yields can be described by single power equations. The 2-year ARI relationship is more complex and has been split into two separate relationships; one representing catchments smaller than 60 km^2 and one for catchments greater than 60 km^2.

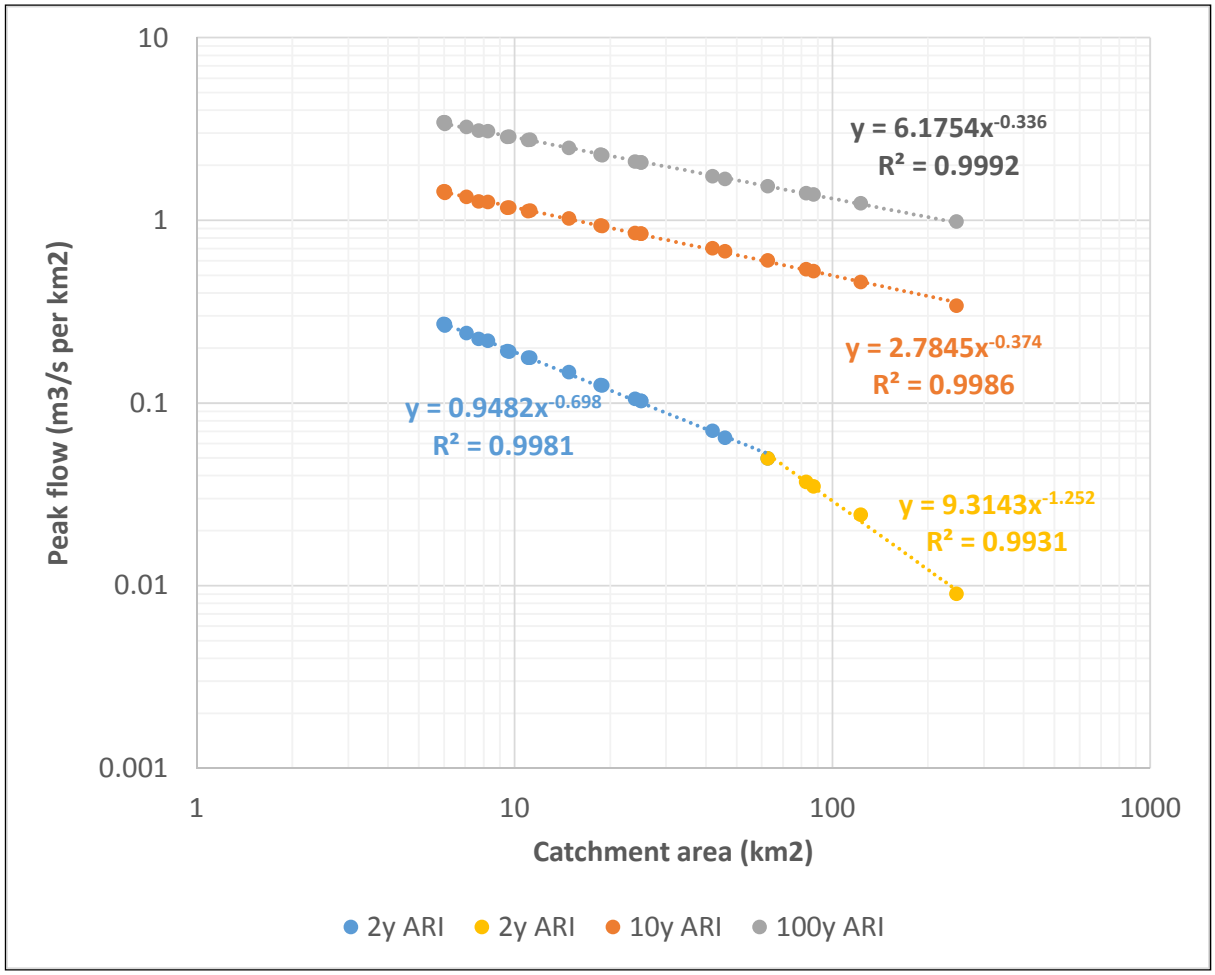


Figure 9-28 Peak flow per km²

The calculated peak flows for the Finke at the haul road crossing (22.8 kilometres) should be validated against recorded data for the Finke at the Stuart Highway (upstream of the haul road) and at the rail crossing (downstream of the haul road).

Catchment flooding

As outlined in Section 9.2.5, rrainfall depths for design storms up to the 100-year ARI event were taken from a BoM IFD. Results indicated that rainfall depths varied by less than 5% between the Stuart Highway and the mine site.

The mine site lies at the foot of an escarpment and a number of drainage lines and ephemeral creeks/gullies drain across the site and onto washout plains. At the mine site boundary, these range in size from about 0.03 to 3.5 km^2; the largest being the catchment that drains to Halfway Dam with a 100-year ARI peak flow of 11.7 m^3/s, and a 2-year ARI peak flow of 1.4 m^3/s. The total catchment area draining to the mine site is 4.1 km^2 (including the Halfway Dam catchment) which would generate the following peak flows:

- 2-year ARI 1.5 m^3/s.
- 10-year ARI 6.7 m^3/s.
- 100-year ARI 13.7 m^3/s.

Drainage through or around the mine site would need to accommodate these peak flows. Short duration (< 3 hours) rainfall does not generally result in significant runoff, as the majority of the rainfall is used to satisfy the initial rainfall loss. The peak flows are generally associated with longer duration rainfall that result in excess runoff. Under these conditions, it would be expected that the mine drainage network would have to manage flood flows for about eight hours.

Road flooding

Peak flows and time-series hydrographs have been derived for each of the catchments crossed by the access road and haul road between the mine site and the Stuart Highway. In total, the access and haul roads cross a significant watercourse or flow line 20 times over a total distance of 90 kilometres. At each of these locations, there is the potential for the haul road to be flooded or to pond water (if the road is carried on an embankment across the floodway).

A detailed DEM of the road alignment between the mine site and the railhead allowed an assessment of the depth and duration of flooding, and the length of road affected. Between the railhead and Stuart Highway (proposed Henbury Access Road), a detailed assessment is not practical due to the absence of a high-resolution DEM, though an estimate of the flood risk at the Finke River crossing (22.8 kilometres) has been made.

For the catchments between the Chandler Facility and railhead (Chandler Haul Road), the DEM was used to define the main channel and floodway cross-section, and the channel gradient. The Mannings flow formula (with a Mannings 'n' roughness of 0.04) was then used to calculate the:

- Depth of flooding over time.
- Velocity of water over time.
- Length of road flooded.
- Duration of flooding.

The results are presented in Table 9-15.

It is assumed that the road could be passable with shallow flooding (< 100 mm). Therefore, the length of time that the maximum flood depth along the road exceeds 100 mm is also noted, as is the length of road affected by flooding of more than 100 mm.

Table 9-15 Chandler Haul Road flood risk – 100-year ARI

Crossing (distance from Stuart Highway)	Peak flow	Max. depth	Maximum velocity	Flood hazard	Length of road flooded		Duration of flooding	
					Water on road	>100 mm flooding	Water on road	>100mm flooding
km	*m^3s^{-1}*	*m*	*ms^{-1}*		*m*	*m*	*hours*	*hours*
59.6	50.2	1.00	0.94	Medium	79	72	30	22
65.7	37.7	0.48	0.63	Low	159	154	26	14
67.9	30.6	0.29	0.60	Low	148	103	24	9
69.0	19.9	0.30	0.50	Low	154	143	18	8
71.0	27.0	0.60	0.77	Medium	69	43	19	16
72.8	19.3	0.60	0.44	Medium	205	107	15	12
78.3	26.6	0.50	0.65	Medium	107	103	24	18

Based on this assessment, peak water velocities are not high and are not the principal driver behind flood hazard at the crossings (Figure 9-29). Rather, the maximum depth of flooding puts some of the crossings into the medium hazard category, with the crossing at 59.6 kilometres verging on the high category. These categories represent the risk to life of entering the floodwaters.

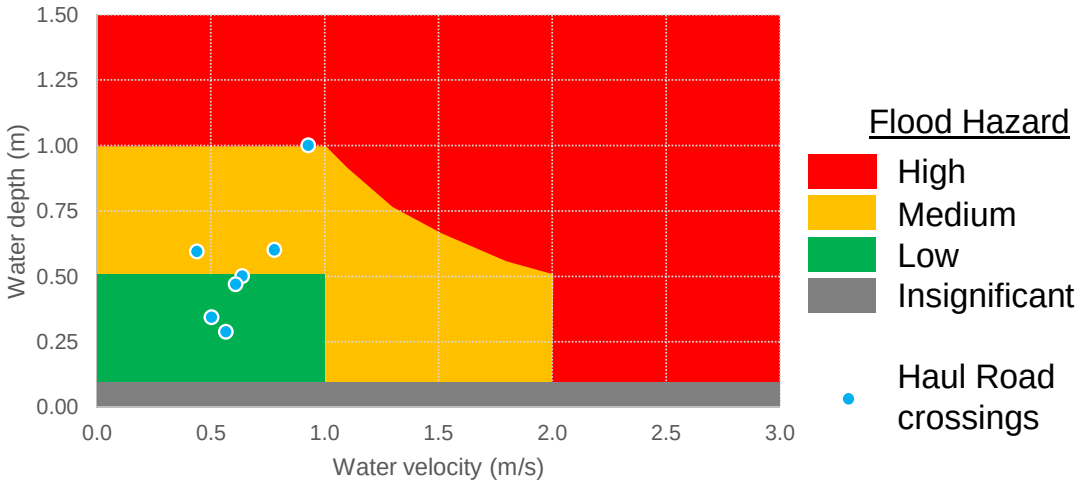


Figure 9-29 Flood hazard at Chandler Haul Road Crossing

While the assessment was limited to those crossings where high definition DEM data was available and a reasonably well-defined drainage line could be identified, it is assumed that the flow depths, velocities and lengths of road flooded are representative of all crossings along the haul road.

The modelling approach assumed that all of the flow passes over the road, and that the road is not raised above local ground level. As such, it is the worst case flooding scenario. The information would inform the road design, including options to mitigate flooding of the road, such as road raising and the use of culverts or bridges to pass flow. Such crossings would not be expected to interrupt

natural streamflow and geomorphological processes. However, post-event maintenance may be required to ensure road usability

Apirnta Facility

The detailed DEM includes the proposed Apirnta Facility, which is about 2 kilometres north of the existing rail crossing. The Facility lies about halfway along an 8 km^2 catchment draining to the haul road. Figure 9-30 shows the location of the facility and contour lines that indicate that the facility intercepts the catchment drainage path, which has a slope of 0.4%. With an upstream catchment area of about 4 km^2, the peak 100-year flow would be about 13 m^3/s.

This would need to be diverted around, or through, the site. For example, a 5 metres wide channel with 4:1 side slopes and a roughness of n = 0.04, a flow of 13m^3/s would have a depth of 1.1 metres and a velocity of 1.3 m/s.

The area shown as the railhead facility in Figure 9-30 is about 0.4 km^2; which equates to 10 % of the catchment upstream of the railhead facility and 5 % of the catchment draining to the haul road.

Developing the Apirnta Facility and associated railhead would result in an increase in impervious area, and potentially a corresponding increase in runoff from the site, though it is understood that the Proposal intention is to capture stormwater runoff from this site for reuse, such as dust suppression.

It is anticipated that this runoff would be intercepted for water quality treatment, which would have the additional benefit of attenuating flows and mitigating any increase in peak flows of volumes down to acceptable levels. The storage capacity for capturing all storm water could be significant for larger design events. The design requirements for this storage system are beyond the remit of this assessment and would be addressed in detailed design and later updated within the Proposal's draft Water Management Plan attached in Appendix Q.

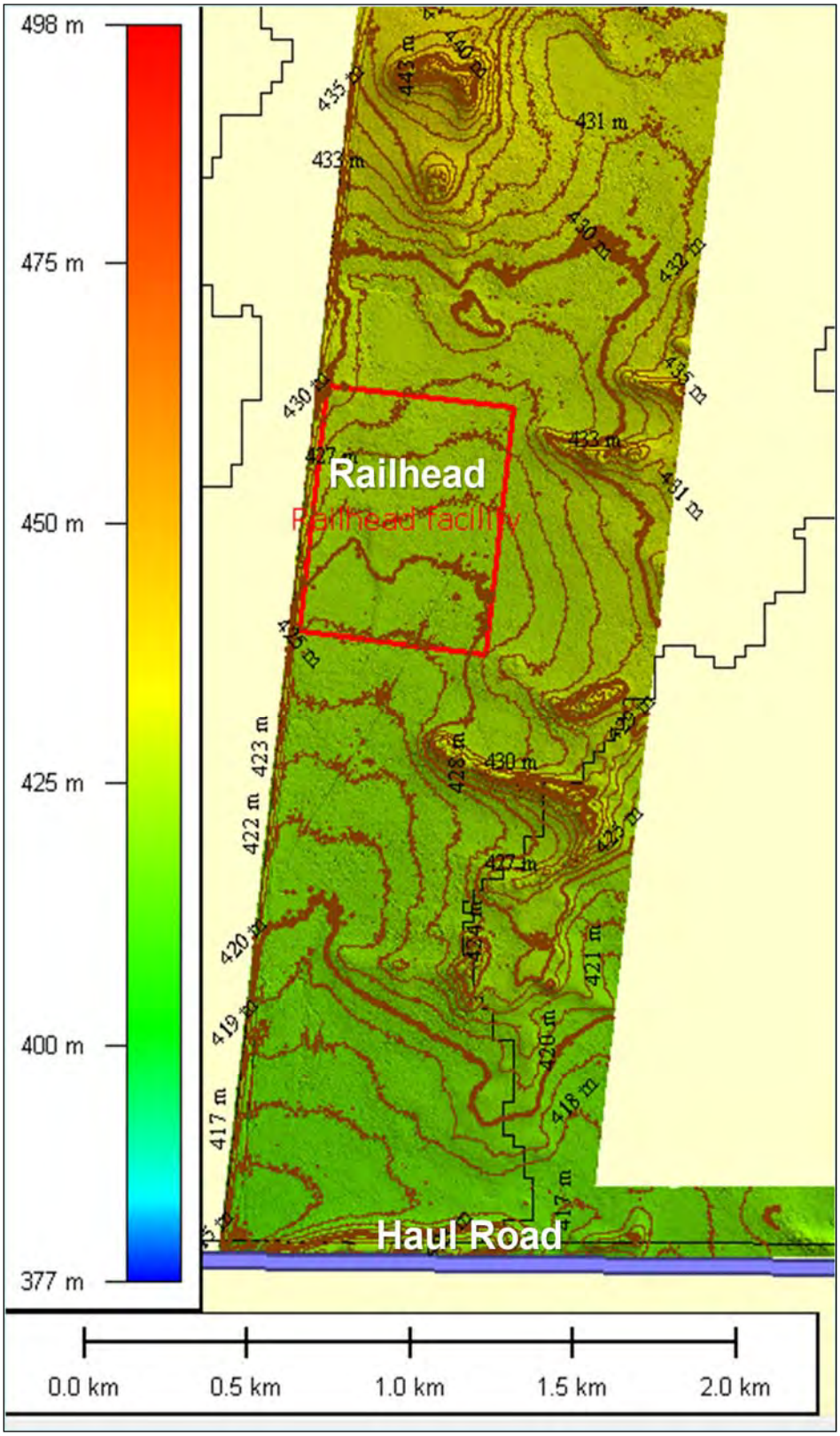


Figure 9-30 Topography at the proposed Apirnta Facility

Runoff from mine stockpiles

Uncontrolled sediment runoff from large stockpile can cause blockage of drainage systems, leading to increases in flood risk, maintenance costs for the stormwater infrastructure owner, road safety risks and mosquito issues. Sedimentation of waterways with coarse particulate matter could lead to increases in flood risk, channel instability, weed infestation and maintenance costs as well as loss of essential aquatic habitats.

The release of fine sediments, including salt laden sediments, into waterways adjacent to the Proposal have potential to increase the concentrations of particulate-bounds metals and nutrients, reduce light penetration and adversely affect the health of semi-aquatic life in temporary refuge pools.

Management measures to avoid and/or control unintentional release of sediments is detailed in Section 9.7.

9.5 Assessment of risk during operation

This section presents the potential impacts (both direct and indirect) on surface water during operation of the Proposal. Mitigation measures to avoid or reduce these impacts are discussed in Section 9.7

9.5.1 Direct impacts

The potential for direct impacts on surface waters during operation are considered to be the same issues raised as direct impacts during construction. Therefore, this section cross references to Section 9.4.1 for potential direct impacts during operation.

9.5.2 Indirect impacts

Section 9.4.2 provides a detailed assessment of flood risk during construction of the Proposal. The issues addressed in that section would also apply to indirect impacts during operation. In addition, the potential impacts of uncontrolled run-off from mine stock piles is also discussed in Section 9.4.2.

9.6 Assessment of risk during closure and rehabilitation

This section presents the potential impacts (both direct and indirect) on surface water during closure and rehabilitation of the Proposal. Mitigation measures to avoid or reduce these impacts are discussed in Section 9.77.9.

9.6.1 Direct impacts

The potential for direct impacts on surface waters during closure and rehabilitation of the Proposal are considered to be the same issues raised as direct impacts during construction. Therefore, this section cross references to Section 9.4.1 for potential direct impacts during closure and rehabilitation. Mitigation measures to avoid or reduce these impacts are discussed in Section 9.7 and in Appendix N7.9.

9.6.2 Indirect impacts

The potential for indirect impacts on surface waters during closure and rehabilitation of the Proposal are considered to be the same issues raised as direct impacts during construction. Therefore, this section cross references to Section 9.4.1 for potential direct impacts during closure and rehabilitation. Mitigation measures to avoid or reduce these impacts are discussed in Section 9.7 and in Appendix N7.9.

9.7 Mitigation and monitoring

Mitigation and management measures proposed to minimise the impacts on surface water during construction, operation, and closure and rehabilitation of the Proposal are listed in Table 9-16. These measures would be incorporated into the Sediment and Erosion Plan (Appendix L), Water Management Plan (Appendix Q) and the Rehabilitation Closure Plan (Appendix J) for the Proposal. These plans would be included into a Construction Environmental Management Plan and Operation Environmental Management Plan.

Table 9-16 Mitigation and management measures (surface water)

ID	Outcome	Mitigation/management measure	Timing
SW1	Management of floodwater draining towards the Chandler Facility from the Maryvale Hills upstream of the mine site.	Formalise drainage channels through or around the site so that upstream runoff does not cause flooding of the site, and so that it is not contaminated by site runoff or sedimentation (refer to Figure 9-31). Raise flood prone site infrastructure above surrounding ground level. Diversion channels should be designed according to best practice guidance including sizing and lining type (IECA, 2008). Estimates of water volumes generated during storm events at the three sites are given in the Flood and Hydrology Assessment for different return periods. These diversion channels would reduce the amount of “dirty water” requiring management, improve wet weather access to the sites and limit erosion and sediment mobilisation on the sites.	Detailed design and pre-construction
SW2	Improved water quality and attenuation of surface water flow.	Treat runoff to improve water quality resulting in an attenuation of flows, mitigating any increase in runoff peak flows or volumes.	Pre-construction
SW3	Movement or reconfiguration of Halfway Dam.	Investigate current and future use of the Halfway Dam. Develop proposals to move or reconfigure the dam and intake.	Pre-construction
SW4	Management of floodwater on Chandler Haul Road.	Manage floodwater by: • Raising the road above surrounding ground level to prevent flooding. • Installing culverts to pass flood flow and reduce/minimise upstream ponding. • Installing causeways over which floodwaters in excess of the design event	Pre-construction

ID	Outcome	Mitigation/management measure	Timing
		can pass, but that raise the road above frequent flood levels. • Carrying out repairs, following flood events, as necessary.	
SW5	Minimisation of impacts from the Henbury Access Road at the Finke River crossing.	Limit the engineering required to cross the river.	Construction
SW6	No long term alterations to local hydrology.	Allow natural surface drainage to continue without interruption, where possible.	Construction
SW7	No long term alterations to local hydrology.	Avoid clearing or disturbance to watercourses or drainage depressions, where possible.	Construction
SW8	No long term alterations to local hydrology.	Avoid infrastructure developments in any watercourse or drainage depressions, where possible.	Construction
SW9	No long term alterations to local hydrology.	Ensure no impedance to natural creek flow, where possible.	Construction
SW10	No long term alterations to local hydrology.	Develop creek crossings to natural contours of creek bed.	Construction
SW10	No long term alterations to local hydrology.	Remove any concentrations points that would impede natural sheet flow.	Construction
SW12	No long term alterations to local hydrology.	Ensure minimal disturbance within watercourse buffer zones.	Construction
SW13	No long term alterations to local hydrology.	Leave large mature trees and shrubs, where possible.	Construction
SW14	No long term alterations to local hydrology.	Conduct routine inspection and maintenance of drains and watercourses.	Construction, operation, closure and rehabilitation
SW15	Avoidance of spills or accidental loss of hazardous materials.	Store hazardous waste within a bunded area sufficient to hold 110% of all material.	Construction, operation, closure and rehabilitation
SW16	Additional monitoring	Undertake level/flow measurements on Halfway Dam catchment and three to four catchments draining to the Chandler Haul Road or Chandler Facility, and including the catchment draining through the Apirnta Facility.	Pre-construction; construction, closure and rehabilitation.
SW17	Additional investigations during detailed design	Develop stormwater models of the Chandler Facility and Apirnta Facility, including the management of site runoff and the diversion /conveyance of floodwaters from upstream catchments around the sites.	Pre-construction
SW18	Additional investigations during detailed design	Develop two-dimensional modelling of flow paths and inundation in the mine lease area, including the 'washout area' to better understand the potential for floodwaters to reach the Hugh River near Titjikala. This investigation would include an assessment of infiltration and evaporation.	Pre-construction
SW19	Additional investigations during detailed design	Model flood risk and scour protection at the crossing of the Finke River.	Pre-construction

ID	Outcome	Mitigation/management measure	Timing
SW20	Additional investigations during detailed design	Model flood risk[28] of haul crossings (bridges, culverts, causeways) of drainage lines.	Pre-construction
SW21	Develop site specific water quality guidelines	Develop guidelines for both the no-flow and flowing phases. This could be done by collecting and interrogating monitoring data and developing conceptual, probabilistic and/or numerical models that incorporate flow, catchment and in-stream influences. This site-specific system would be developed during detailed design and as part of the Water Management Plan and relies on obtaining more site data.	Pre-construction
SW22	No offsite sedimentation	Improving water retention by slowing upstream surface flow and improving transmission properties, which provides more time for water to infiltrate	Pre-construction and Construction
SW23	Preventing erosion and sedimentation	Decreasing runoff rate and its velocity by providing appropriate surface drainage systems for safe conduct of water into pre-designed surface storage systems (Section 5	Pre-construction
SW24	No offsite pollution	Silty or oily water should not be used for dust suppression purposes, because this would transfer pollutants to the haul roads or generate more dust	Construction and operation
SW25	No offsite release of salt laden sediment	A clay lined drainage swale would be constructed around the perimeter of the run of mine salt stock pile to prevent offsite release of salt laden sediment	Operation
SW26	Prevent sediment from being tracked off site and onto the road	It is recommended that one entry / exit point to the Apirnta Facility and Chandler Facility sites should be established. If the site slopes towards this entry / exit, drainage and sediment control devices should be installed so that all sediment laden runoff can be fully contained and treated on-site	Pre-construction
SW27	Prevent sediment from being tracked off site and onto the road	Vehicles and construction equipment may require washing to prevent transfer and accumulation of mud on the haulage and access roads. Alternatively, manned jet washes or lance sprays could be used in a bunded area where the runoff can be contained and channelled to a treatment area, such as a settlement pond.	Construction and operation
SW28	Best practice in stockpile management	Soil and sand stockpiles need to be located within the compound and upslope of a sediment control. Impervious covers, filter fences, mulch berms or sediment fences.	Construction and operation
SW29	Prevent sediment runoff	Provision of a sediment trap, such as a mulch bank or a sediment fence, on the downslope boundaries of the Apirnta Facility, Chandler	Construction and operation and closure

[28] *The modelling would include an expanded suite of design events, including extreme events such as the Probable Maximum Flood*

ID	Outcome	Mitigation/management measure	Timing
		Facility and haulage roads is recommended. The mulch banks and sediment fencing should be positioned on the contour where possible	
SW30	Prevent sediment runoff	Onsite drop inlet pits and haulage road side entry pits should be protected prior to the commencement of works or as soon as constructed	Construction and operation and closure
SW31	Prevent sediment runoff	Buffer strips and vegetation filters should be employed, where practical, along the haulage road instead of sediment trapping structures (DLRM, 2013b)	Construction and operation and closure
SW32	Best possible location for the replacement of Halfway Dam	Make use of a similar gully or depression off-line from an adjacent to a creek with similar catchment area nearby on gently sloping terrain (<15%). A site investigation and selection should be undertaken to optimise the sustainable use of available water within a dam's catchment. The size of the catchment, soil and vegetation characteristics and path of surface run-off water determines what water is available within a catchment. Contour maps should be used to predict the path of rainfall and irrigation run-off within the dam's catchment.	Detailed design
SW33	Prevent the release of stormwater offsite	Stormwater from disturbed areas would not be discharged into down-gradient properties. To capture 'dirty' surface runoff, u-shaped earth banks would be constructed to pond water (DLRM, 2013b).	Detailed design and pre-construction
SW34	Provide habitat and prevent erosion	Retained vegetation can have the dual purpose of not only assisting in the settling of sediment from overland flows, but also provide a refuge for flora and fauna.	Construction and operation.
SW35	Prevent erosion and sedimentation	A disturbance plan would be prepared following the completion of detailed design. This would be done to retain or preserve as much of the existing vegetation as possible would be implemented, especially adjacent to drainage lines. Identification of any areas to be used as 'turn around' or laydown areas should be completed with an indication in the Construction Notes how cleared and NO-GO areas would be implemented e.g. GPS data provided to clearing contractors and areas flagged on the ground prior to any clearing activity.	Pre-construction
SW36	Retain riparian vegetation and prevent offsite release of sediments.	DLRM Land Clearing Guidelines provide information on required buffer zones for watercourses (DLRM, 2013a and DLRM, 2013b). To be effective as a sediment control, the area for retention should contain at least 80% ground cover. Buffer zones for the Apirnta Facility, Chandler Facility, and Haulage Roads have been developed based	Construction and operation

ID	Outcome	Mitigation/management measure	Timing
		on stream order. The bulk of buffer zones are 25 metres. The exception is Charlotte Creek, a second order stream, requiring a buffer of 50 metres.	

Aeolion dune & swales
aligned northwest - southeast and up to 5 m

CH002
existing Tellus groundwater
monitoring bore

Proposed development footprint

CH001
existing Tellus groundwater
monitoring bore

Flood out zone
alluvial sands
highly erosive

Remnant flood out zone. Original flow path cut off by halfway dam. Existing Red Bloodwoods experience significant dieback due to lack of surface water recharge.

Mary's Gully

Propsed cutoff drain diverting
clean water away from the
mine infrastructure area

Proposed
culvert

Maryvale Hills (~480 m AHD)

Dingo Gully

Roo Gully

Clay pan or arid
zone wetland

Halfway Basin

Halfway Creek

Proposed ROM
stockpile zone

Active bank erosion

Halfway Creek

Legend

- Existing access road
- Watercourse
- Vegetation
- Indicative batter slope
- Proposed development footprint
- Proposed cutoff drain
- Proposed culvert

Figure 9-31
Proposed surface water diversions
within the mine infrastructure area

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use.
Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data supplied by Department of Land Resource Management.
Copyright Northern Territory of Australia.
Created by:apmiller

8.11 Summary of risk assessment

A summary of the risk assessment undertaken for surface water during construction, operation, closure and rehabilitation of the Proposal is provided in Table 9-17.

Table 9-17 Summary of surface water risk assessment

Hazard	Pre-mitigated risk			Post-mitigated risks			Risk outcome
	Likelihood	Consequence	Risk ranking	Likelihood	Consequence	Risk ranking	
Surface water ingress into decline area and general mining infrastructure	Likely	Moderate	High	Remote	Moderate	Low	Risk reduced
Contaminated surface water runoff off-site	Unlikely	Minor	Low	Remote	Minor	Low	Risk reduced
Salt dissolution and transport off-site	Likely	Major	High	Remote	Minor	Low	Risk reduced
Flash flooding into mine infrastructure area	Possible	Major	High	Remote	Moderate	Low	Risk reduced
Flooding of access/haul roads	Likely	Moderate	High	Possible	Minor	Medium	Risk reduced
Soil erosion leading to excess sedimentation in watercourses	Possible	Major	High	Remote	Minor	Low	Risk reduced
Contamination of regional surface waters (Hugh and Finke Rivers) through loss of containment	Remote	Major	Medium	Eliminated	Major	Eliminated	Risk reduced
Contamination of Hugh River through loss of containment	Remote	Major	Medium	Eliminated	Major	Eliminated	Risk reduced
Contamination of Finke River through loss of containment	Remote	Major	Medium	Eliminated	Major	Eliminated	Risk reduced
Altered hydrology surrounding Maryvale Hills	Almost certain	Moderate	High	Almost certain	Minor	High	Risk reduced
Altered hydrology surrounding the mine infrastructure area	Almost certain	Major	Extreme	Almost certain	Major	Extreme (Beneficial)	Risk same

9.8 Conclusion

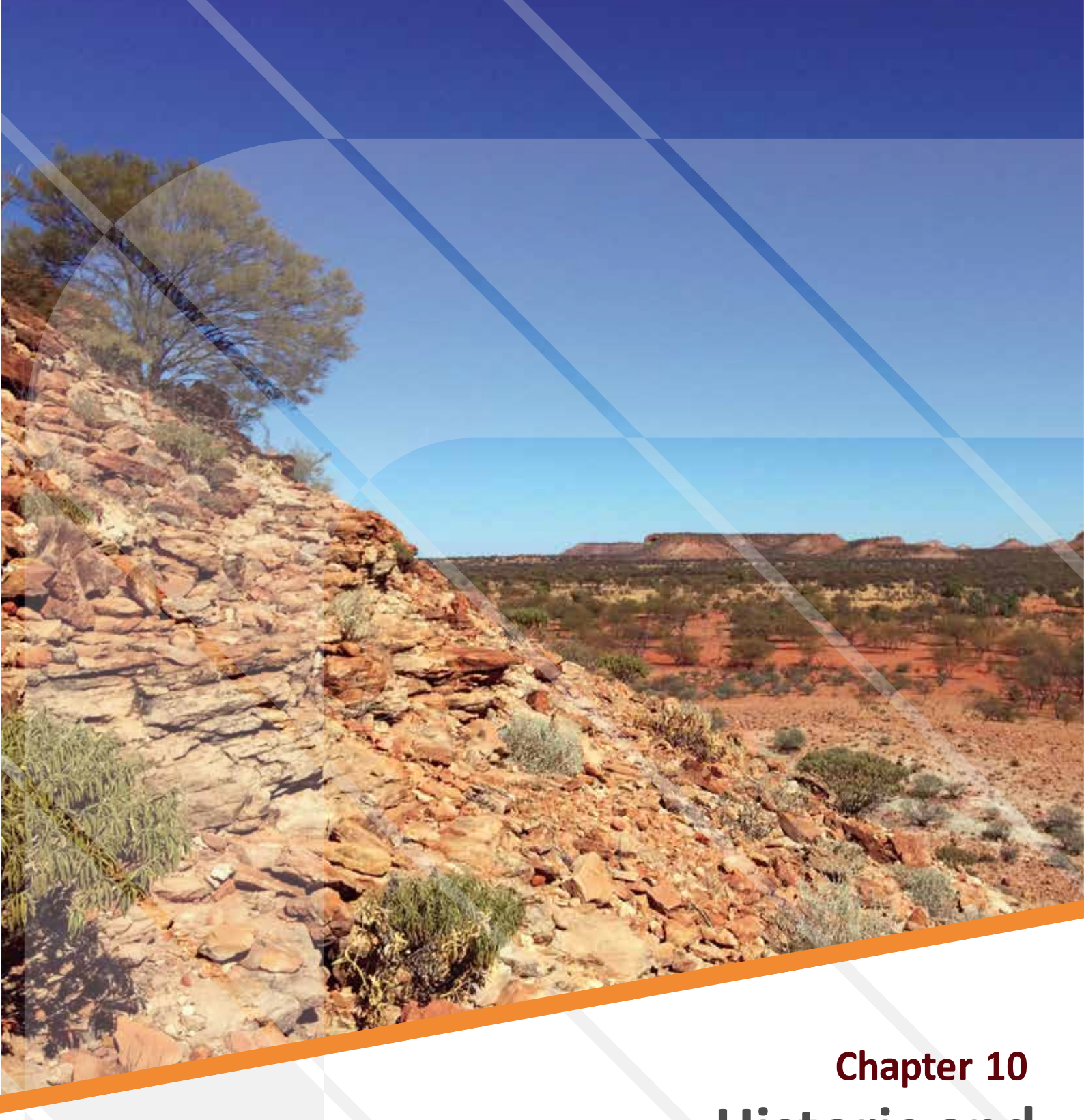
The Proposal is located in a remote, dry and sparsely populated part of the NT. Watercourses in the region are generally dry for the majority of the year. Rainfall is seasonal, with the potential to generate large flood events. Due to generally dry antecedent conditions, the first rain to fall is needed to satisfy the moisture demand of the surface layer, with runoff generated from rain later in the storm.

Without suitable mitigation, flooding has the potential to affect the mine site, Apirnta railhead facility and haul road. Mitigation would be required to divert / convey flood flows from upstream catchments past the mine site and Apirnta railhead facility, and to manage stormwater falling on both sites. Stormwater management would include water quality treatment (not considered in this report).

Where the access and haul road crosses drainage lines, the road could be closed for up to 24 hours following the 100-year ARI 9-hour storm unless mitigation measures (, culverts or causeways) are incorporated into the road design. The crossing of the Finke River (between Apirnta and the Stuart Highway) could require a bridge, if that section of road is to be kept open.

If managed correctly, the remote location of the Proposal limits the potential for the associated infrastructure to adversely affect other communities or environment. The changes in hydrological regime due to the mine site development are unlikely to be observed at the Titjikala community near the Hugh River, as the affected area is a small percentage of the contributing catchment and hydrological connectivity from the proposed mine site area through the washout zone and dunes to the Hugh River is unlikely.

Due to the site's aridity and its isolated location, surface water data is not comprehensive. However, as outlined in Section 9.7, the proponent is committed to further field work, data collection and modelling to verify the results of research undertaken for this EIS.



Chapter 10

Historic and Cultural Heritage

This page has been left intentionally blank

10 HISTORIC AND CULTURAL HERITAGE

10.1 Introduction

This chapter provides a review of cultural heritage values that may be potentially affected by the Proposal. This chapter draws on a comprehensive cultural heritage impact assessment, which is included as Appendix S. This chapter describes the historic and archaeological heritage values at the site of the proposed Chandler Facility, Apirnta Facility and the proposed Chandler Haul Road and Henbury Access Road. The potential impacts on cultural heritage values are assessed and mitigation and management measures are identified to reduce potential impacts. A Cultural Heritage Management Plan is provided in Appendix S.

The assessment has been prepared in consultation with the NT Heritage Branch as well as with Traditional Owners. It has also been prepared in accordance with the Terms of Reference.

This chapter does not address sacred sites protected under the NT *Aboriginal Sacred Sites Act*. A number of sacred sites have been identified within the proposed development footprint by the Central Land Council and the Aboriginal Areas Protection Authority. These sites would be managed in accordance with the conditions of an Aboriginal Areas Protection Authority Certificate.

10.2 Methodology

The methodology for the cultural heritage impact assessment included consultation, a database and literature review, the development of predictive models, field surveys and assessments of significance.

10.2.1 Consultation

Consultations were undertaken with the Central Land Council and the Aboriginal Areas Protection Authority in the course of obtaining sacred sites clearances.

Consultation was also undertaken with the NT Heritage Branch regarding previously recorded cultural heritage sites within and in the vicinity of the proposed development footprint. Consultation was undertaken with Traditional Owners regarding the cultural significance of archaeological sites recorded within the proposed development footprint during the field surveys. Consultation was undertaken over the phone, at their principal place of residence and at the site of the proposed Chandler Facility, Apirnta Facility, Chandler Haul Road and part of the Henbury Access Road. Further consultation with Traditional Owners will be completed during detailed design and prior to construction of the Proposal.

10.2.2 Database and literature review

A desktop assessment was undertaken to determine the nature and status of known cultural heritage sites within and in the vicinity of the proposed development footprint and to guide the field surveys.

The desktop assessment included searches of heritage registers and schedules and a review of local histories and archaeological reports. Searches were undertaken of the following heritage registers and schedules:

- NT Heritage Register (NT Heritage Council).
- National Heritage List (Australian Heritage Council).
- Register of the National Estate (Australian Heritage Council).
- Commonwealth Heritage List (Australian Heritage Council).
- World Heritage List (United Nations Educational, Scientific and Cultural Organization (UNESCO)).

The result of previous archaeological research undertaken in the region were reviewed. A comprehensive list of the literature reviewed is provided in Appendix S. This data informed the development of predictive models which were subsequently tested in the field and refined accordingly.

10.2.3 Development of predictive models

The cultural heritage impact assessment involved the development of predictive models (an environmental model and an ethnographic model) to predict the location of cultural heritage sites within the proposed development footprint, and to guide the field surveys.

The environmental model

Under the environmental model, the timing and pattern of land use is tied to water availability and resource abundance, reflecting an emphasis on optimal foraging strategies. Land use focusses on areas around permanent water sources and that whenever possible people will position themselves in areas where there are maximum available resources for least effort (that is, they will target areas richest in resource diversity, commonly occurring where two or more different land systems and/or landforms meet). Opportunistic land use also occurs as people position themselves within the landscape to take advantage of temporary abundances of particular resources, for example, focussing on resources in the vicinity of ephemeral water sources after rain.

Under this model, archaeological material is expected to occur most frequently and in higher densities in the vicinity of water sources (creeks, rivers, swamps, flood outs and claypans), where two or more land units/forms meet, in the ranges, and at isolated low hills and rocky outcrops suitable for raw (stone) material extraction. Away from these areas, on the sand dunes and sand plains, archaeological material is expected to occur infrequently and in low densities.

More specifically, quarries and knapping floors will occur in and around rock outcrops and in the ranges. The frequency, size and density of artefact scatters will be directly correlated with distance from water sources as well as the type of water source. For example, large high density artefact scatters will occur nearby large permanent water sources, moderate sized artefact scatters of moderate size and density may be found nearby large ephemeral water sources, while small, low

density artefact scatters and background scatters may be located along small ephemeral creeks. It is expected that assemblages exhibiting a greater degree of richness and diversity will be found in close proximity to two or more land units/forms, reflecting the greater diversity of resources available in these areas.

The ethnographic model

Under the ethnographic model, country such as the sand hills and mulga plains are generally subject to fleeting ephemeral use, while areas in the vicinity of permanent water sources such as springs and waterholes, which themselves tend to be found in the ranges, are subject to more or less continuous use. Small groups moved across the landscape from one permanent water source to another, periodically joining other groups for ceremonial activities and when food and water resources were abundant. In the latter circumstances camps could be established nearby ephemeral water sources. While most camps will be situated in close proximity to water sources, large camps may also occur up to 5km away these areas.

Given the absence of permanent water sources in the proposed development footprint, it is likely that the predominant type of land use in the area was based on the opportunistic exploitation of resources periodically available after large rainfall events and fleetingly while travelling through the area and/or while out hunting and gathering resources during the day and returning to a base camp located at a permanent water source outside of the proposed development footprint. The archaeological signature of this type of land use is predicted to be as follows:

- Small, low density sites, background scatters and isolated finds are likely to be the most common site types found in the sandhill and mulga country. In these areas the diversity of stone raw materials and artefact types will be low.
- Large high and moderate density sites are likely to be the most common site types found in the vicinity of permanent water sources in the ranges. Stone artefact assemblages in these areas will be richer and more diverse.
- High and moderate density sites with moderately rich and diverse assemblages may occur in the vicinity of large ephemeral water sources.
- Large sites may occur within a 5 kilometre radius of water sources.
- Generally, the most common artefacts will be those associated with wood-working such as axes, tulas and sharp flakes. Artefacts associated with seed processing are also likely to be common such as grindstones and muellers.

A refined predictive model is described in Section 10.3.6.

10.2.4 Field surveys

The objectives of the field surveys were to:

- Characterise the archaeological signature of the land systems and land forms of the area.

- Test the predictive models.
- Inspect those areas known to have a high probability of being impacted by the Proposal.

The field surveys were conducted over four days in November and December 2015 and over three days in March 2016. The field surveys consisted of both random and purposive pedestrian transects and slow moving vehicle transects.

A total of 83.94 kilometres was surveyed of which 55.15 kilometres were pedestrian transects, as indicated in **Table 10-1**. Further information on each transect including detailed mapping showing the location of each transect is provided in Appendix S.

Table 10-1 Summary of transects surveyed

Location[29]	Pedestrian transects (km)	Slow (<5km/hour) moving vehicle transects (km)	Total (km)
Chandler Facility	24.96	12.59	37.56
Chandler Haul Road	3.38	0.79	4.17
Apirtna Facility	2.65	2.18	4.83
Henbury Access Road	24.16	13.23	37.39
Total	**55.15**	**28.79**	**83.95**

The criteria employed for identifying flaked stone artefacts (cores, unretouched flakes, retouched flakes and flaked pieces) was based on those defined by Hiscock (1984 and 1988). Additional artefact types that were likely to be located in the area including tula flakes, backed artefacts, edge ground axes, grindstones, hammerstones and manuports were identified based on the characteristics defined by McCarthy (1976), Hiscock and Veth (1991), Hiscock and Attenbrow (1996) and Holdaway and Stern (2004).

The criteria employed for identifying site types (components) including artefact scatters, knapping floors, stone quarries, ochre quarries, art sites, rockshelter sites, stone arrangements, grinding sites, modified trees and burial sites was based on those defined by Hiscock and Mitchell (1993), Gregory (1988) and Thorley (1998).

While the NT *Heritage Act* defines Aboriginal and Macassan archaeological places and objects, archaeologists frequently employ arbitrary criteria in order to be able to distinguish between areas subject to intensive occupation and those subject to fleeting or ephemeral use and because it is not usually considered practical to record all individual artefacts as sites when undertaking consultancy work. For the purposes of this assessment, an *artefact scatter* (as opposed to a background scatter), would have three characteristics (after Thorley 1998):

[29] *Note: Not all of the proposed Chandler Haul Road or Maryvale Access Road was surveyed. This was due to uncertainties of the route at the time of the field surveys. Additional survey work would be undertaken in these areas prior to construction.*

- More than five artefacts within an area less than 100 square metres.
- A maximum artefact density greater than 1/20 square metres.
- Be more than 50 metres from the nearest artefact scatter.

Isolated finds usually comprised only one or two artefacts in close proximity to each other with no other artefacts within a minimum 25 metre radius. At the other end of the spectrum, site complexes contained one or more of the site types referred to above, and tended to be large and complex (hence the term), containing evidence of numerous activities, usually focussed on resource rich areas in the landscape.

10.2.5 Assessments of significance

Assessments of significance were prepared for historic and archaeological sites/objects recorded in the proposed development footprint. This included an assessment of both historic places and objects and an assessment of sites recorded in the proposed development footprint.

Historic significance

The assessment of significance for historic places and objects included consideration of aesthetic, historic and social values in addition to scientific significance. These values are defined in the *Australia ICOMOS Charter for the Conservation of Places of Cultural Significance* (commonly referred to as the "Burra Charter", Australia ICOMOS 1987) and in Section 11 of the NT *Heritage Act*, as follows:

a) whether it is important to the course, or pattern, of the Territory's cultural or natural history;

b) whether it possesses uncommon, rare or endangered aspects of the Territory's cultural or natural history;

c) whether it has potential to yield information that will contribute to an understanding of the Territory's cultural or natural history;

d) whether it is important in demonstrating the principal characteristics of a class of cultural or natural places or environments;

e) whether it is important in exhibiting particular aesthetic characteristics;

f) whether it is important in demonstrating a high degree of creative or technical achievement during a particular period;

g) whether it has a strong or special association with a particular community or cultural group for social, cultural or spiritual reasons, including the significance of a place to Aboriginal people as part of their continuing and developing cultural traditions;

h) whether it has a special association with the life or works of a person, or group of persons, of importance in the Territory's history.

Archaeological significance

The assessment of significance for archaeological sites included an assessment of both archaeological significance and cultural significance to Traditional Owners.

The archaeological significance of archaeological material was assessed following *Site Surveys and Significance Assessment in Australian Archaeology* (Sullivan and Bowdler 1984) and the *Burra Charter* (Australia ICOMOS 1987). Sullivan and Bowdler (1984) equate archaeological significance with scientific significance and identify two elements that should be assessed: the potential of the material to address timely and specific research questions and the representativeness of the material.

Similarly, the *Burra Charter* states that the scientific value or research potential of a place depends upon the importance of the data involved, on its rarity, quality or representativeness, and on the degree to which the place or object may contribute to further substantial information (Maquis-Kyle and Walker 1992). Accordingly, the significance of a site is related to the intactness or integrity of a site, that is, the state of preservation as well as the stratigraphic reliability of the cultural material. Secondly, the representativeness of a site is important either because a site is unusual or because the site has research potential when taken in conjunction with other sites.

The cultural significance of the site was determined based on advice from Traditional Owners.

10.3 Existing environment

This section describes the landscape and cultural context of the proposed development footprint and vicinity. Previously recorded sites within and in the vicinity of the proposed development footprint are summarised and the results of the field surveys are presented. A summary of the assessments of significance is also provided.

10.3.1 Landscape context

The proposed development footprint is located within the Finke Bioregion, which spans an area of approximately 73,800 square kilometres from northern South Australia into the NT. It has an arid and hot climate with very low rainfall and high evaporation. The bioregion is characterised by red sand plains and there are also areas with hills and valleys. Major rivers include the Finke River, Hugh River and Palmer River, all in the NT. The vegetation is mostly tussock grasslands, acacia shrublands (dominated by mulga) and chenopod and samphire shrublands. Land within the bioregion is predominately used for grazing cattle (Neave *et al* 2004).

The distribution of various land systems within the proposed development footprint as described in the *General Report on Lands of the Alice Springs Area, Northern Territory,1956-57* (Perry *et al* 1960) is provided in **Table 10-2**. Essentially, elevated ranges, rocky hills and outliers and undulating stony country primarily occurs in the Rumbalara, Chandler and Gillen land systems and are dominant

features in the area of the proposed Chandler Facility and the western third of the Henbury Access Road (refer to Plate 10-1).

Sand plains of the Angas and Singleton land systems are characteristic of parts of the proposed Chandler Facility, the Apirnta Facility and part of the Henbury Access Road (refer to and Plate 10-2).

The Simpson land system with its characteristic spinifex and desert oak covered red sand dunes dominates the middle section of the proposed Henbury Access Road. The sandy river plains of the Finke land system occur in only a small area of the Henbury Access Road, including and immediately adjacent to, the Finke River. A small section of the Henbury Access Road also traverses part of the Renner land system, consisting of undulating limestone country.

Land systems within the proposed development footprint are shown graphically in Figure 4 and Figure 5 in Appendix S.



Plate 10-1 Section of Rumbalara land system



Plate 10-2 Section of Angas land system, west of the Finke River

Table 10-2 Summary description and distribution of land systems within the proposed development footprint

Land system	Description	Landforms and plant communities	Occurrence in the proposed development footprint
Rumbalara (Ru)	High stony plateaux, including mesas up to 100 m high formed on weathered shale in the dissected margin of the Simpson Desert.	Channels either treeless or with *Acacia aneura* (mulga) over curly windmill grass; alluvial fans and valley floors with absent or sparse low trees or mulga over short grasses and forbs; erosional slopes either bare or with sparse shrubs and low trees or mulga over saltbush, bluebush, samphire, *Eremophila* spp., or *A. kempeana* over short grasses and forbs; plateaux and mesas, stony summits, breakaways and steep hill slopes with shallow stony soils supporting no vegetation or sparse shrubs and low trees or mulga over sparse grasses and forbs.	Chandler Facility
Chandlers (Cn)	Flat-topped hills and broadly undulating stony lowlands, these hills may be up to around 85m high.	Channels with *A. aneura* and kangaroo grass; cuestas and mesas, stony summits and breakaways with outcrop and shallow stony soil supporting sparse shrubs and low trees (mulga) or *A .calcicola* (myall) over grasses and forbs or *A .kempeana* over short grasses and forbs; valley floors with *Eremophila sp.*over cottonbush or bluebush with *E. microtheca* in depressions with lignum; alluvial fans and small clay pans supporting no vegetation or *Eremophila* spp. over samphire, bluebush or saltbush; erosional slopes and stony surfaces with minor outcrop bands supporting no vegetation or *Eremophila* spp. over samphire, bluebush or saltbush.	Henbury Access Road
Gillen (Gi)	Sandstone ranges and vales running east-west with some ridges up to 300m high.	Channels with *Eucalyptus .microtheca* (coolabah), *E. camuldensis* (river red gum) and *A. estrophiolata* (ironwood) over *Chloris acicularis*; sparse low trees, grasses and forbs on floodplains and alluvial plains; colluvial and alluvial fans either treeless or with *A. aneura* (mulga) over short grasses, sparse shrubs and low trees over spinifex (*Triodia basedowii*); stony erosional slopes either treeless or with *Eremophila* spp., short grasses; stony gravel terraces either treeless or with mulga and spinifex or short grasses; stony soils and rock outcrop on ridges, cuestas, foothill ridges, benches and mesas with sparse shrubs and low trees typically mulga, *A .kempeana,-Cassia* spp, over short grasses and spinifex.	Chandler Haul Road
Angas (An)	Sand plain and dunes, and strongly undulating stony plains. It usually adjoins the hillier Chandlers land system in its higher parts.	Channels, alluvial plains and valley floors with cottonbush; slopes of strike ridges covered with short grasses and forbs (bluebush); strike ridges, broader rises and slopes with shallow stony soils supporting no vegetation or witchetty bush over short grasses and forbs; sand plains with low dunes covered with sparse shrubs and low trees over spinifex or *A. aneura* (mulga) over short grasses and forbs.	Apirnta Facility and Henbury Access Road

Land system	Description	Landforms and plant communities	Occurrence in the proposed development footprint
Singleton (Sn)	Spinifex sand plain	Alluvial flats and drainage floors with *A. aneura* (mulga) or *E. microtheca* (coolabah) over short grasses; sand rises with sparse shrubs and low trees over spinifex; swales (flat floors) with mulga over short grasses; sand plains or hummocky surfaces fixed by vegetation such as sparse shrubs and low trees including *Casuarina decaisneana* (desert oak) over spinifex (*Triodia* spp and *Plectrachne* spp).	Chandler Facility and Henbury Access Road (eastern section)
Simpson (Si)	Spinifex covered sand dunes	Dune crests (hummocky unstable surfaces) with *Zygochloa* spp. (desert cane grass); dune flanks with *C. decaisneana* (Desert oak) over spinifex (*Triodia* spp and *Plectrachne* spp); swales with minor drainage channels and alluvial flats and claypans. Varied vegetation including *A. aneura* (mulga) or *E. microtheca* (coolabah) over samphire or old-man saltbush.	Chandler Facility and Henbury Access Road

10.3.2 Cultural context

Aboriginal occupation of the central arid zone of Australia began at least 32,000 years ago. Aboriginal occupation seems to have intensified during the Late Pleistocene, and by around 30,000 years before present, groups of highly mobile hunter-gatherers were using pockets of country across the interior of the continent (Smith 2006). Occupation of the central arid zone appears to have intensified during the Holocene as environmental conditions (particularly the availability of water) improved.

Within the vicinity of the proposed development footprint, the land was traditionally and semi-traditionally occupied by members of an Arandic-speaking people, known as Pertame or Southern Arente. The language spoken was referred to as Twertentye. Neighbouring language groups, comprising Luritja-speaking people, namely the descendants of the Lower Southern Arrente (Alyentharrpe) and Matuntara-speaking people also retain some spiritual and residential connection to the area. These people moved opportunistically across the landscape but were tethered to base camps with more reliable water sources during times of drought, spreading out over the country after rain. Generally, groups comprised one or two families that travelled together with larger gatherings periodically held for ceremonial purposes.

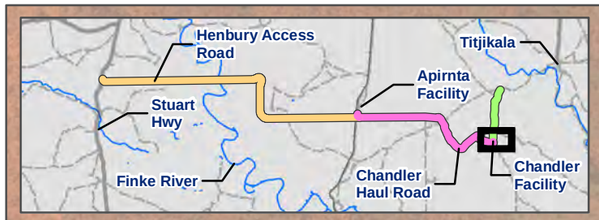
The first Europeans to traverse the district were the early explorers, and later those men engaged on the construction of the Overland Telegraph Line in the early 1870s. Aboriginal encounters with explorers were fleeting during this time. Overall, the impact on traditional land use patterns was negligible compared to the arrival of European graziers and their cattle in the late 19th century. The nature of these impacts varied but generally included:

- Depopulation as a result of punitive expeditions and retaliatory killings, introduced diseases, changes in diet and drought.
- Dispossession, loss of access to land and traditional resources.
- Change from a nomadic hunting and gathering existence to a more sedentary way of life.
- Disregard for, and damage to, sacred sites.
- Changes in material culture; and changes in social organisation.

Further detail regarding the cultural context of the proposed development footprint and vicinity is provided in Appendix S.

10.3.3 Cultural heritage exclusion zones

Consultation with traditional owners undertaken in 2013 identified three areas of cultural sensitivity within the vicinity of the proposed Chandler Facility. Following those consultations, the proponent mapped the three areas of cultural sensitivity as areas of exclusion for the Proposal. These are shown in **Figure 10-1**.



MULGA CREEK

MARYS CREEK

OAK GULLY

RIDEY GULLY

SNAKE GULLY

DINGO GULLY

ROO GULLY

HALFWAY CREEK

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Document Path: C:\GIS_SS\Maps\Chandler_Heritage_SMA_AccessTijikalaShown.mxd

N

250 125 0 250 Meters

Coordinate System:
GDA 1994 MGA Zone 53

Legend

Proposed development footprint

- Access road to Titjikala
- Chandler Haul Road
- Chandler Facility
- Pastoral boundaries
- Cultural heritage exclusion zone
- Watercourse
- Existing track

Figure 10-1
Cultural heritage exclusion zones

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller

10.3.4 Previously recorded sites

There are no sites listed on the NT Heritage Register, National Heritage List, Register of the National Estate, Commonwealth Heritage List or the World Heritage List recorded within the proposed development envelope.

Five previously recorded archaeological sites are known to occur within the vicinity of the proposed development footprint (all of which are protected under the NT *Heritage Act*): Maryvale Hills 1 through Maryvale Hills 5 (MVH1 through MVH5). Two of these sites (MVH1 and MVH4) are located within exclusion zones associated with sacred sites identified by the Central Land Council. Another (MVH5) was situated outside the proposed development footprint. MVH3 was re-located and re-recorded in the field as 'MVH3 Revised' and found to comprise a much larger area than initially recorded. MVH2 was unable to be re-located during the field surveys; it may have been washed away or otherwise destroyed in the interim, or alternatively the location data was incorrect (refer Appendix S for further detail).

10.3.5 Sites recorded during current survey

No historic places were recorded within or in the vicinity of the proposed development footprint during the field surveys. One historic item was, however, recorded. This was a Bells brand tin matchbox, located outside of the proposed development footprint.

A range of archaeological site types including artefact scatters, knapping floors, stone quarries and an ochre quarry were recorded during the field surveys (refer to Plate 10-3 and Plate 10-4). Fifty-one sites were recorded (of which 30 were a part of eight larger site complexes). Outside of these site complexes, nine background scatters and 26 isolated finds were also recorded. A breakdown of the archaeological material recorded within the proposed development footprint is as follows:

- **Chandler Facility**. Thirty-one sites, two background scatters and 11 isolated finds were recorded in the area of the proposed Chandler Facility (refer to Table 10-3 and Figure 10-2). Nineteen of the 31 sites were a part of six larger site complexes. Overall, the most common site type recorded were artefact scatters, followed by knapping floors and stone quarries.
- **Apirnta Facility**. A background scatter and three isolated finds were recorded in the area of the proposed Apirnta Facility (refer to Table 10-4 and
- Figure 10-3).
- **Chandler Haul Road**. Three sites and five isolated finds were recorded in the area along the proposed Chandler Haul Road (refer to Table 10-5 and
- Figure 10-4). The site types recorded included three artefact scatters and one stone quarry, in addition to background scatters.
- **Henbury Access Road**. Seventeen sites, six background scatters and seven isolated finds were recorded in the area along the proposed Henbury Access Road (refer to Table 10-6 and

- Figure 10-5). Eleven of the 17 sites recorded were part of two larger site complexes. Overall, the most common site type recorded were artefact scatters, followed by knapping floors. Two stone quarries and one ochre quarry was also recorded.

The distribution of archaeological material recorded within the proposed development footprint by land system and landform is described in further detail in Appendix S.



Plate 10-3 Retouched/grinding implement, ground and pitted surface (left), other side (middle), retouch/use-wear along edges (right)



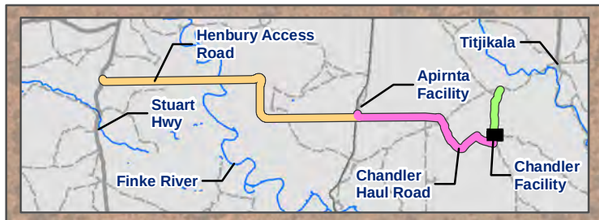
Plate 10-4 Broken unifacially retouched flake, possibly a broken unifacial point, dorsal (left) and bulbar (right) surfaces

Table 10-3 Summary of archaeological material recorded within the area of the proposed Chandler Facility

Complex name	Site name	Site type/components	Land system(s)	Landform(s)	Site size (m^2)	Max. artefact density/m^2
-	CS1	Artefact scatter	Singleton	Sand plain next to flood-out	20	0.25
-	CS2	Artefact scatter	Singleton	Sand plain	28	5
-	CS3	Artefact scatter	Intersection Rumbarala and Singleton	Sand plain	210	15
-	CS4	Background scatter	Singleton	Sand plain	125	1.5
-	CS5 – Desert Oak Site	Knapping floor	Simpson	Sand plain	2.25	3
-	CS6	Artefact scatter	Intersection Rumbalara, Singleton and Simpson	Creek/drainage channel and flood-out	400 (min)	5
-	IFWP41	Isolated find (1)	Intersection Rumbalara, Singleton and Simpson	Edge of flood-out next to dune	-	-
-	CS7	Isolated finds (2)	Rumbalara/Singleton	Sand plain	-	-
Southern Claypan Site Complex	CS8	Isolated finds (2)	Intersection Rumbalara, Singleton and Simpson	Dune slope next to claypan	-	-
	CS9	Knapping floor	Intersection Rumbalara, Singleton and Simpson	Base of dune next to claypan	3	100
	CS10	Isolated finds (2)	Intersection Rumbalara, Singleton and Simpson	Dune slope next to claypan	-	-
	CSx	Artefact scatter	Intersection Rumbalara, Singleton and Simpson	Edge of claypan	N/A	5
	IFWP42	Isolated find (1)	Intersection Rumbalara, Singleton and Simpson	Plains adjacent to claypan	-	-
-	Transect 5 BGS	Background scatter	Rumbalara	Edge of creek/drainage channel	-	-
-	T5IF	Isolated find (1)	Rumbalara	Edge of creek/drainage channel	-	-
-	CS11	Artefact scatter	Rumbalara	Dune at base of range	2,992	20

Complex name	Site name	Site type/components	Land system(s)	Landform(s)	Site size (m^2)	Max. artefact density/m^2
Portal 2 Site Complex	CS12	Isolated finds (3)	Rumbalara	Overhang/rockshelter on middle slopes	-	-
	CS13	Knapping floor	Rumbalara	Sand plains at base of range	6	20
	CS14 The Pass	Artefact scatter, quarry, background scatter	Rumbalara	Rocky saddle and lower slopes of range	3,300	20
	CS15	Knapping floors (2)	Rumbalara	Sand plains at base of range	400	10
CS16 Site Complex	CS16a	Artefact scatter	Rumbalara and Singleton	Dune slope next to claypan	200	10
	CS16b	Background scatter	Rumbalara and Singleton	Sand plains adjacent to claypan	-	-
	CS16c	Artefact scatter	Rumbalara and Singleton	Isolated low rocky hill and sandplains near claypan	34,000	10
-	T25IF	Isolated finds (1)	Singleton	Sand plains and flood-out	-	-
-	T26IFa	Isolated finds (1)	Singleton	Sand plains and flood-out	-	-
-	T26IFb	Isolated finds (2)	Singleton	Sand plains and flood-out	-	-
Tellus Camp Site Complex	Tellus Camp 1	Artefact scatter, background scatter	Rumbalara	Lower slopes of range, red sands adjacent to drainage channel	150	10
	Tellus Camp 2	Knapping floor, artefact scatter	Rumbalara	Relic dune	300	6
	Tellus Camp 3	Artefact scatter	Intersection Rumbalara and Singleton	Relic dune, sand plains	600	5
-	CS17	Artefact scatter, background scatter	Rumbalara	Lower slopes of range	25	5
-	MVH3 Revised	Stone quarry, artefact scatter	Rumbalara	Top of range, upper and lower slopes of range, valley, rocky outcrops, drainage line, sand plains	52,000	10
-	T9 Site	Artefact scatter	Intersection Rumbalara and Singleton	Dune slope	100	5
CS18 and 19 Site Complex	CS18a	Artefact scatter	Rumbalara	Dune	25	10
	CS18b	Knapping floor	Rumbalara	Dune	6.25	50
	CS18c	Artefact scatter	Rumbalara	Dune slope	100	30
	CS18d	Artefact scatter	Rumbalara	Sandy slopes next to rock outcrop	25	5

Complex name	Site name	Site type/components	Land system(s)	Landform(s)	Site size (m^2)	Max. artefact density/m^2
	CS18e	Stone Quarry	Rumbalara	Rock outcrop	540	N/A
	CS19	Stone quarry, artefact scatter	Rumbalara	Rock outcrop	16,000	100
-	T18IF	Isolated find (1)	Intersection Rumbalara and Singleton	Sand plains	-	-
-	CS21	Artefact scatter, background scatter	Intersection Rumbalara and Singleton	Sand plains	2,800	3
-	CS 20	Isolated finds (2)	Intersection Rumbalara and Singleton	Sand plain	-	-
-	CS22	Knapping floor	Intersection Rumbalara and Singleton	Sand plain	5	7
WT6 Bore Site Complex	WT6 BSCa	Artefact scatter	Rumbalara	Low sand dune on plain	5,625	5
	WT6 BSCb	Stone quarry, artefact scatter	Rumbalara	Low rocky outcrop at base of range	612	50
	WT6 BSCc	Knapping floor, artefact scatter	Rumbalara	Sand plain	4.5	12
-	CS23	Artefact scatter	Intersection Rumbalara and Singleton	Sand plain	88	3



CS23
MULGA CREEK
MVH1(approx)
WT6 Bore Site Complex - AS
WT6 Bore Site Complex - Quarry
CS22
CS20
WT6 Bore Site Complex - KF
CS21
T18 IF Silcrete flake
MARYS CREEK
CS19
CS18a
CS18b
CS18c
CS18e
CS18d

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Document Path: C:\GIS_SS\Maps\Chandler_Heritage_SMA_AccessTiikalaShown.mxd

N

75 37.5 0 75 Meters

Coordinate System:
GDA 1994 MGA Zone 53

Legend

Proposed development footprint

- Access road to Titjikala
- Chandler Facility
- Pastoral boundaries
- Cultural heritage exclusion zone
- Watercourse
- Existing track

Archaeological significance

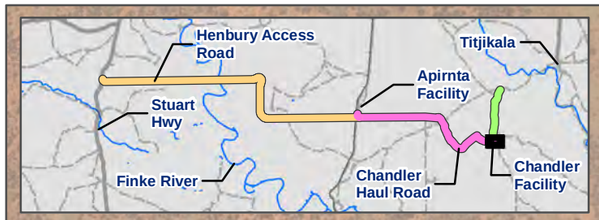
- No archaeological significance recorded
- Low to very low
- Low to moderate
- High to very high

Figure 10-2 (Sheet 1)
Archaeological material recorded in the area of the proposed Chandler Facility

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller



T9 site

OAK GULLY

MHV3 Revised

MVH3

CS17

RIDEY GULLY

SNAKE GULLY

DINGO GULLY

ROO GULLY

Tellus Camp 3

Tellus Camp 2

Tellus Camp 1

HALFWAY CREEK

T26 IFa

T26 IFb

MVH2 (approx)

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Document Path: C:\GIS_SS\Maps\Chandler_Heritage_SMA_AccessTijikalaShown.mxd

N

100 50 0 100 Meters

Coordinate System:
GDA 1994 MGA Zone 53

Legend

Proposed development footprint

- Access road to Titjikala
- Chandler Haul Road
- Chandler Facility

- Pastoral boundaries
- Cultural heritage exclusion zone
- Watercourse
- Existing track

Archaeological significance

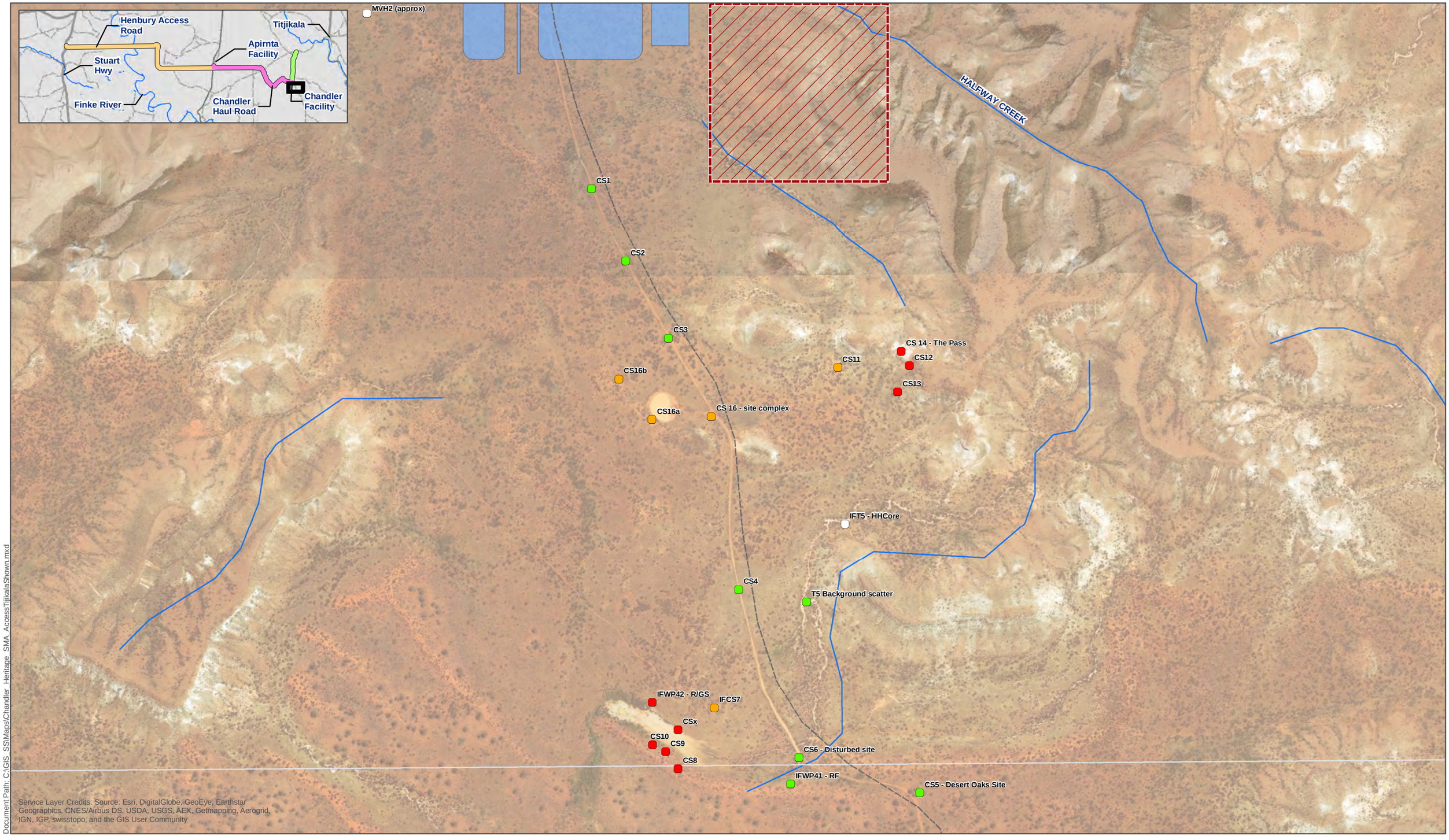
- No archaeological significance recorded
- Low to very low
- Low to moderate
- High to very high

Figure 10-2 (Sheet 2)
Archaeological material recorded in the area of the proposed Chandler Facility

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller



Document Path: C:\GIS_SSMaps\Chandler_Heritage_SMA_AccessTijikalaShown.mxd

N

200 100 0 200 Meters

Coordinate System:
GDA 1994 MGA Zone 53

Legend

- Chandler Facility
- Pastoral boundaries
- Cultural heritage exclusion zone
- Watercourse
- Existing track

Archaeological significance

- No archaeological significance recorded
- Low to very low
- Low to moderate
- High to very high

Figure 10-2 (Sheet 3)
Archaeological material recorded in the area of the proposed Chandler Facility

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller

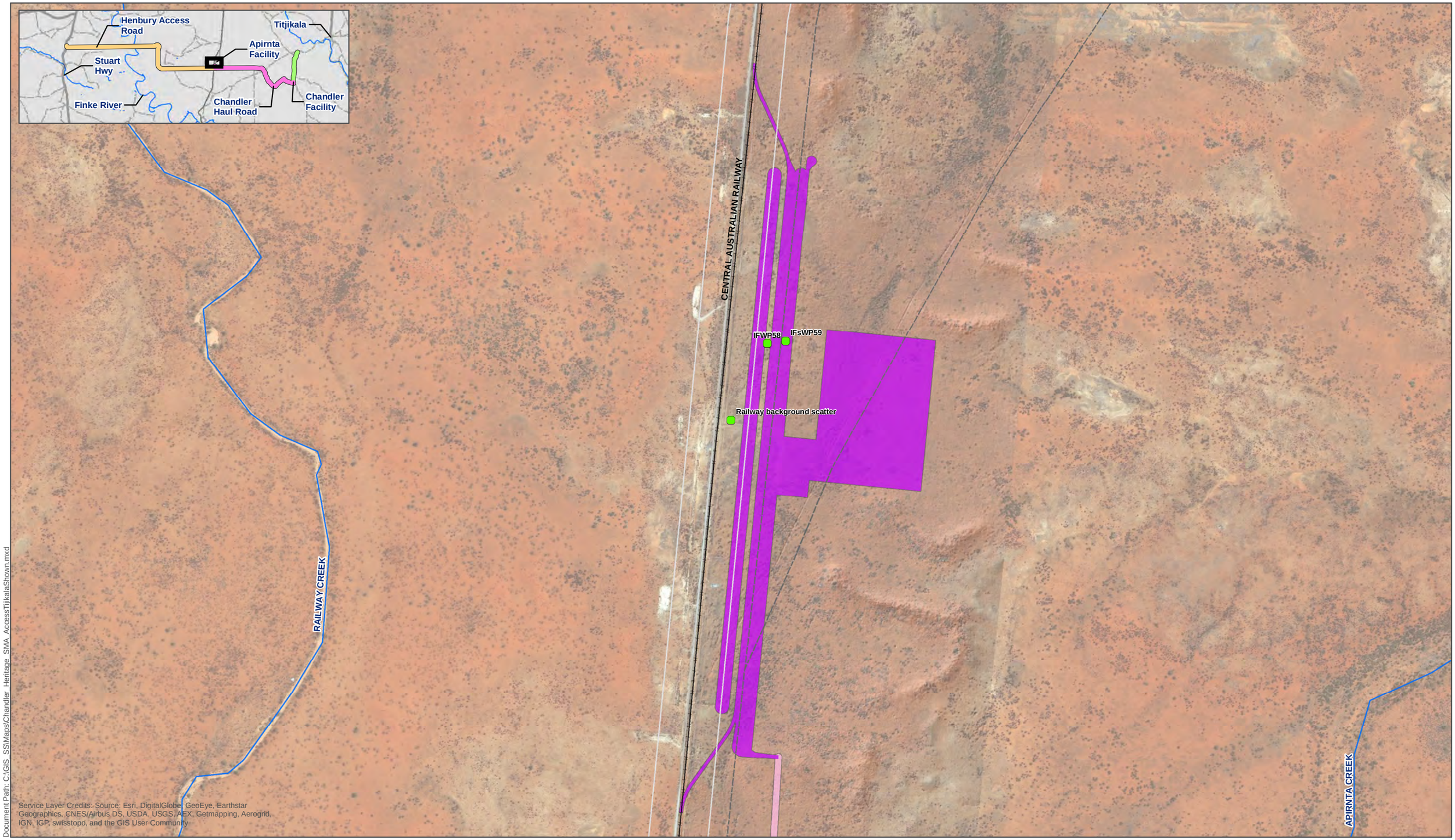


Table 10-4 Summary of archaeological material recorded within the area of the proposed Apirnta Facility

Complex name	Site name	Site type/component	Land system	Landform	Site size (m^2)	Max. artefact density/m^2
-	Railway Siding BGS	Background scatter	Angas	Sand plain with stony gibber	-	-
-	IFWP58	Isolated find	Angas	Sand plain	-	-
-	IFWP59	Isolated finds (2)	Angas	Sand plain	-	-

Table 10-5 Summary of archaeological material recorded within the area of the proposed Chandler Haul Road

Complex name	Site name	Site type/component	Land system	Landform	Site size (area m^2)	Max. artefact density/m^2
-	IFWP88	Isolated find (2)	Gillen	Stony gibber on plains adjacent to drainage channel	-	-
-	IFWP92	Isolated find (1)	Gillen	Stony gibber on plains adjacent to drainage channel	-	-
-	IFWP93	Isolated find (1)	Gillen	Stony gibber on plains adjacent to drainage channel	-	-
-	IFWP94	Isolated find (1)	Gillen	Stony gibber on plains adjacent to drainage channel	-	-
-	No.84 Bore Site 1	Artefact scatter, background scatter	Gillen	Stony gibber on plains adjacent to drainage channel	200	2
-	No.84 Bore Site 2	Artefact scatter, background scatter	Gillen	Stony gibber on stony lower slopes adjacent to drainage channel	1,200	2
-	No.84 Bore Site 3	Stone quarry, artefact scatter	Gillen	Stony gibber on stony lower slopes adjacent to drainage channel; red sands adjacent to flood-out	40,000	5



Document Path: C:\GIS_SSI\Maps\Chandler_Heritage_SMA_AccessTitjikalaShown.mxd

N

200 100 0 200 Meters

Coordinate System:
GDA 1994 MGA Zone 53

Legend

Proposed development footprint

- Chandler Haul Road
- Proposed development footprint - Apirnta Facility
- Pastoral boundaries
- Watercourse
- Existing track

Archaeological significance

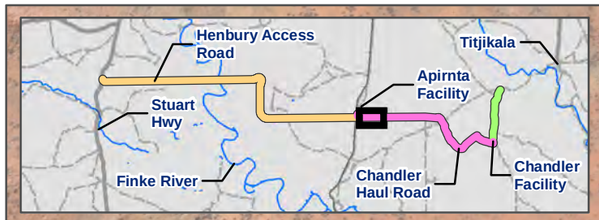
- No archaeological significance recorded
- Low to very low
- Low to moderate
- High to very high

Figure 10-3
Archaeological material recorded in the area of the proposed Apirnta Facility

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller



APIRNTA CREEK

Claypan 2 - central point

Claypan 1 - central point

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Document Path: C:\GIS_SSI\Maps\Chandler_Heritage_SMA_AccessTitjikalaShown.mxd

N

200 100 0 200 Meters

Coordinate System:
GDA 1994 MGA Zone 53

Legend

Proposed development footprint

- Chandler Haul Road
- Henbury Access Road

- Pastoral boundaries
- Watercourse
- Existing track

Archaeological significance

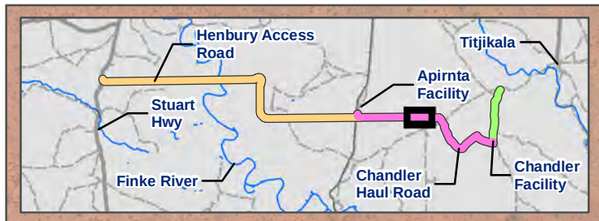
- No archaeological significance recorded
- Low to very low
- Low to moderate
- High to very high

Figure 10-4 (Sheet 1)
Archaeological material recorded in the area of the proposed Chandler Haul Road

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller



Chandlers BGS - central point

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Document Path: C:\GIS_SSMaps\Chandler_Heritage_SMA_AccessTitjikalaShown.mxd

N

200 100 0 200 Meters

Coordinate System:
GDA 1994 MGA Zone 53

Legend

Proposed development footprint

Chandler Haul Road

Pastoral boundaries

Watercourse

Existing track

Archaeological significance

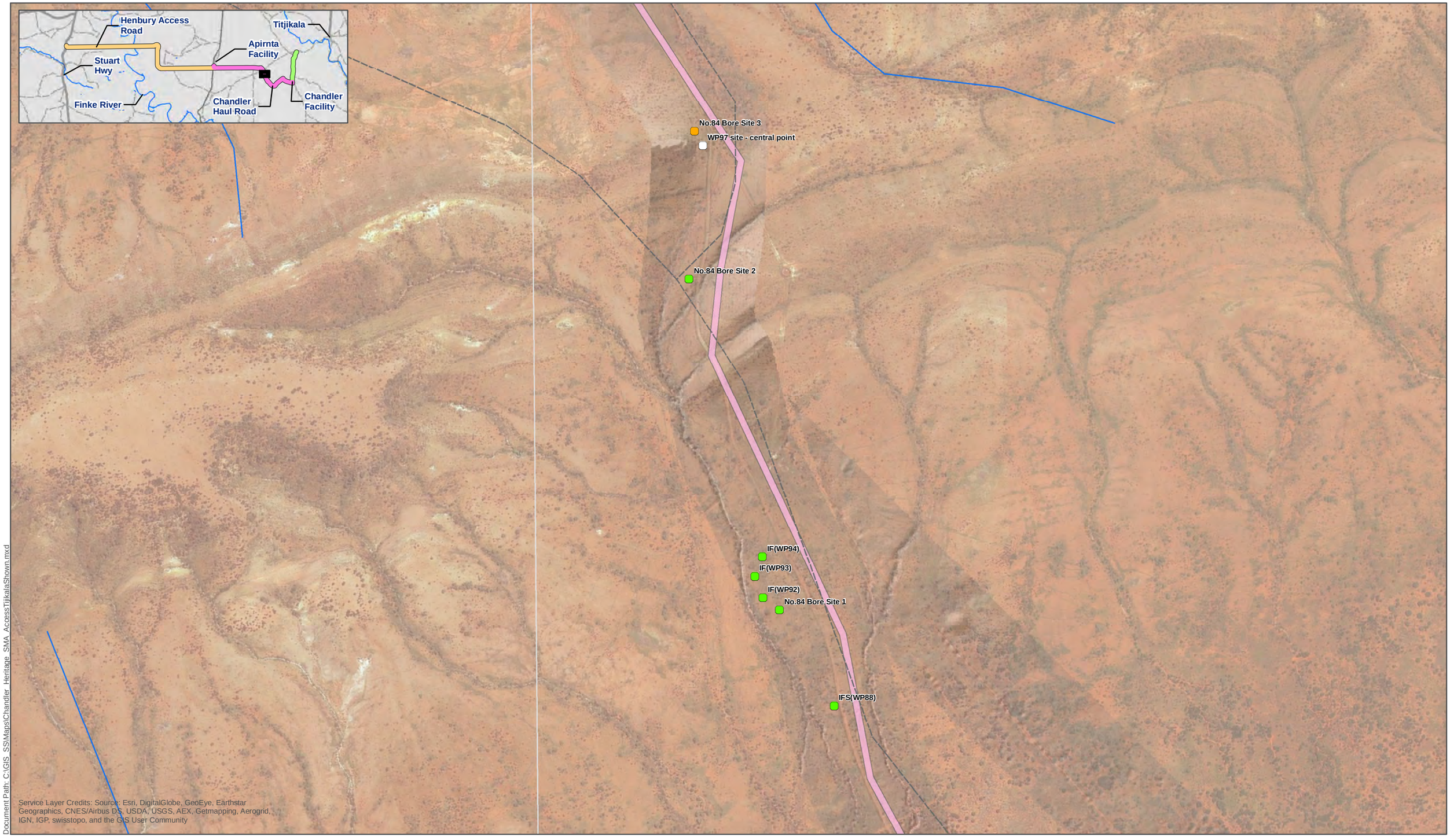
- No archaeological significance recorded
- Low to very low
- Low to moderate
- High to very high

Figure 10-4 (Sheet 2)
Archaeological material recorded in the area of the proposed Chandler Haul Road

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller



Document Path: C:\GIS_SSMaps\Chandler_Heritage_SMA_AccessTiijkalaShown.mxd

N

100 50 0 100 Meters

Coordinate System:
GDA 1994 MGA Zone 53

Legend

Proposed development footprint

Chandler Haul Road

Pastoral boundaries

Watercourse

Existing track

Archaeological significance

- No archaeological significance recorded
- Low to very low
- Low to moderate
- High to very high

Figure 10-4 (Sheet 3)
Archaeological material recorded in the area of the proposed Chandler Haul Road

TELLUS

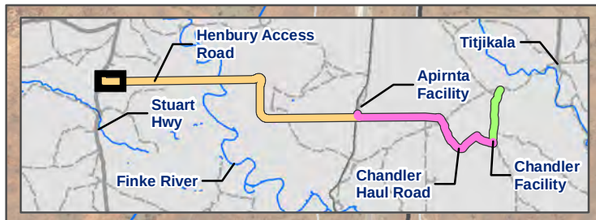
Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller

Table 10-6 Summary of archaeological material recorded within the area of the proposed Henbury Access Road

Complex name	Site name	Site type/component	Land system(s)	Landform(s)	Site size (m^2)	Max. artefact density/m^2
-	Rocky Hills background scatter 1	Background scatter	Chandlers	Lower slopes and top of rocky hills	-	-
-	Rocky Hills background scatter 2	Background scatter	Chandlers	Lower slopes of rocky hills	-	-
-	IFAMWP	Isolated find (1)	Chandlers	Claypan on plains adjacent to creek	-	-
-	Bleak landscape scatter	Background scatter	Chandlers	Sand plain with stony gibber	-	-
-	Stony rises BGS	Background scatter	Chandlers	Low stony rises	-	-
-	WHAR 1	Artefact scatter, background scatter	Angas	Claypan adjacent to isolated low dunes with rocky outcrops on plains	2.25	-
White Rocky Hills Site Complex	White Rocky Hills Site 1 (WRH 1)	Artefact scatter, stone quarry	Chandlers	Lower slopes of rocky hills	94,500	30
	WRH 1b	Artefact scatter	Chandlers	Alluvial flats adjacent to creek and flood-out	85	4
	WRH 2a	Knapping floor	Chandlers	Stony gibber in eroded area of lower slopes of rocky hills	6	-
	WRH 2b	Knapping floor	Chandlers	Stony gibber in claypan on alluvial flats	15	10
	WRH 2c	Knapping floor	Chandlers	Stony gibber in claypan on alluvial flats	6	22
	WRH 2d	Artefact scatter	Chandlers	Claypan on alluvial flats adjacent to flood-out area	400	2
	WRH 3	Artefact scatter	Chandlers	Base of low rocky outcrop adjacent to alluvial flats	20	5
	WRH 4	Artefact scatter	Chandlers	Lower slopes of rocky hills adjacent to low rocky outcrop	460	5
-	T15IF	Isolated find (1)	Chandlers/ Simpson	Sand plains adjacent to creek	-	-
-	Finke River scatter	Artefact scatter	Finke	Levee bank/terraces	40	2
-	T14IF	Isolated find (1)	Renners	Erosional slope/sand plain	-	-

Complex name	Site name	Site type/component	Land system(s)	Landform(s)	Site size (m^2)	Max. artefact density/m^2
-	Duck Swamp IFSa	Isolated finds (2)	Simpson	Edge of swamp adjacent to dune	-	-
-	Duck Swamp IFSb	Isolated find (1)	Simpson	Lower dune slope between swamp and claypan	-	-
-	Duck Swamp IFSc	Isolated find (1)	Simpson	Dune crest between swamp and claypan	-	-
-	Lone Hill Site	Stone quarry, artefact scatter	Singleton	Lower slopes of isolated hill on sand plain	6,300	4
WHAR 3 Site Complex	WHAR 3a	Artefact scatter	Chandlers	Rocky lower slopes of range and rock outcrops	100	2
	WHAR 3b (RS)	Rockshelter, artefact scatter	Chandlers	Rocky upper and lower slopes of range	750	10
	WHAR 3c (OQ)	Ochre quarry, artefact scatter	Chandlers	Rocky lower slopes of range and rock outcrops	4,500	10
-	Chiming Wedgebill background scatter	Background scatter	Intersection Chandlers, Angas and Singleton	Lower rocky slopes adjacent to creek	-	-
-	WHAR 2	Artefact scatter	Angas	Sand plain adjacent to low stony rise	5,000	3
-	Claypan 2 Site	Artefact scatter, background scatter	Simpson	Alluvial flats adjacent to low rocky ridge and claypan	5,000	5
-	Claypan 1 Site	Artefact scatter	Simpson	Edge of claypan and dune slope next to claypan	9,800	10
-	Chandler Jump-up background scatter	Background scatter	Chandlers	Stony gibber on top of rocky range	-	-



STUART HIGHWAY

as noted. not recorded

Rocky Hills BG1

Stony Rises BGS - central point

Rocky Hills BG2

Bleak landscape scatter

Stony rises BGS - easternmost point

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Document Path: C:\GIS_SSMaps\Chandler_Heritage_SMA_AccessTitjikalaShown.mxd

N

200 100 0 200 Meters

Coordinate System:
GDA 1994 MGA Zone 53

Legend

Proposed development footprint

Henbury Access Road

Pastoral boundaries

Watercourse

Existing road

Archaeological significance

No archaeological significance recorded

Low to very low

Low to moderate

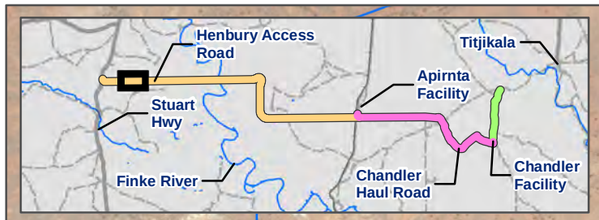
High to very high

Figure 10-5 (Sheet 1)
Archaeological material recorded in the area of the proposed Henbury Access Road

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use.
Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller



WHAR 1 - dune claypan site

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Document Path: C:\GIS_SSI\Maps\Chandler_Heritage_SMA_AccessTitjikalaShown.mxd

N

200 100 0 200 Meters

Coordinate System:
GDA 1994 MGA Zone 53

Legend

Proposed development footprint

Henbury Access Road

Pastoral boundaries

Watercourse

Archaeological significance

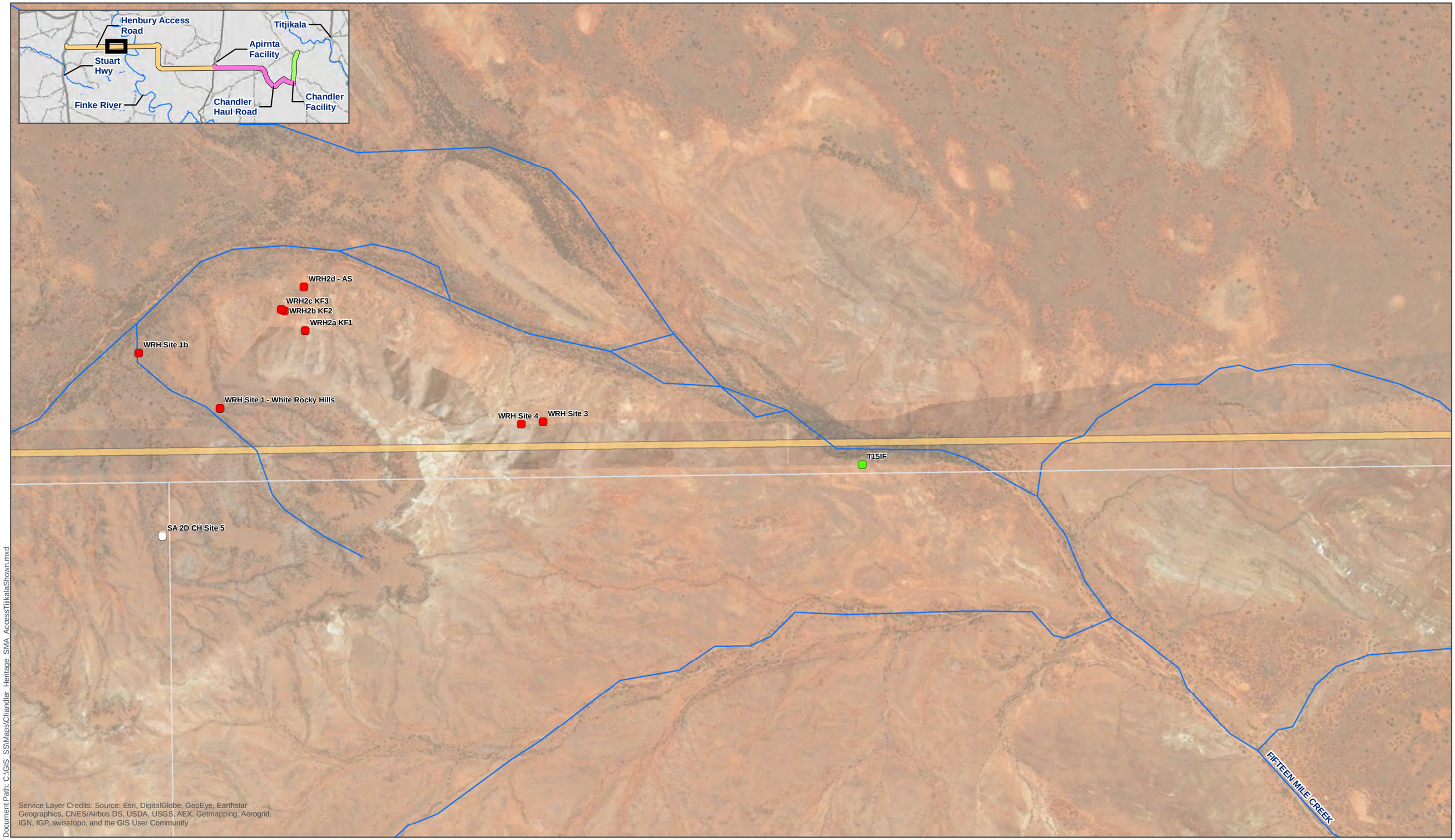
- No archaeological significance recorded
- Low to very low
- Low to moderate
- High to very high

Figure 10-5 (Sheet 2)
Archaeological material recorded in the area of the proposed Henbury Access Road

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller



Document Path: C:\GIS_SS\Maps\Chandler_Heritage_SMA_AccessTijikalaShown.mxd

N

250 125 0 250 Meters

Coordinate System:
GDA 1994 MGA Zone 53

Legend

Proposed development footprint

Henbury Access Road

Pastoral boundaries

Watercourse

Archaeological significance

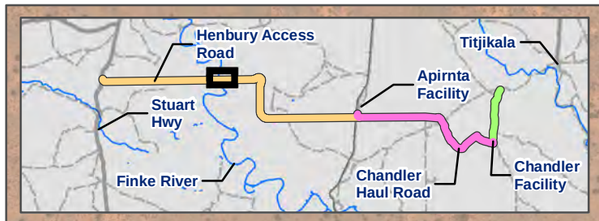
- No archaeological significance recorded
- Low to very low
- Low to moderate
- High to very high

Figure 10-5 (Sheet 3)
Archaeological material recorded in the area of the proposed Henbury Access Road

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller



Finke River scatter

SA 2D CH Site 6

FINKE RIVER

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Document Path: C:\GIS_SS\Maps\Chandler_Heritage_SMA_AccessTitjikalaShown.mxd

N

200 100 0 200 Meters

Coordinate System:
GDA 1994 MGA Zone 53

Legend

Proposed development footprint

Henbury Access Road

Pastoral boundaries

Watercourse

Archaeological significance

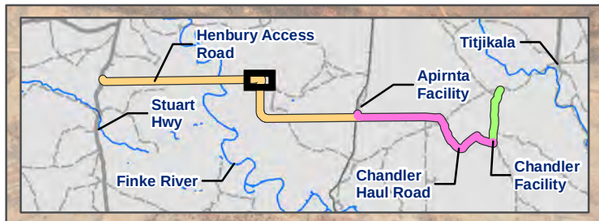
- No archaeological significance recorded
- Low to very low
- Low to moderate
- High to very high

Figure 10-5 (Sheet 4)
Archaeological material recorded in the area of the proposed Henbury Access Road

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use.
Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller



T14IF

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Document Path: C:\GIS_SS\Maps\Chandler_Heritage_SMA_AccessTitjikalaShown.mxd

N

200 100 0 200 Meters

Coordinate System:
GDA 1994 MGA Zone 53

Legend

Proposed development footprint

Henbury Access Road

Pastoral boundaries

Watercourse

Archaeological significance

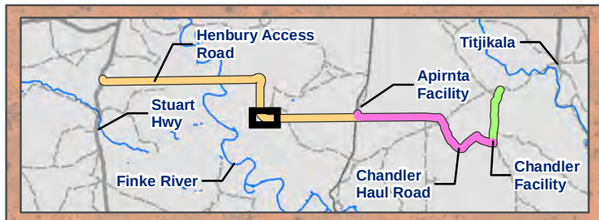
- No archaeological significance recorded
- Low to very low
- Low to moderate
- High to very high

Figure 10-5 (Sheet 5)
Archaeological material recorded in the area of the proposed Henbury Access Road

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller



IFc Duck Swamp

IFb Duck Swamp

IFSa - Duck Swamp

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Document Path: C:\GIS_SSI\Maps\Chandler_Heritage_SMA_AccessTitjikalaShown.mxd

N

200 100 0 200 Meters

Coordinate System:
GDA 1994 MGA Zone 53

Legend

Proposed development footprint

Henbury Access Road

Pastoral boundaries

Watercourse

Archaeological significance

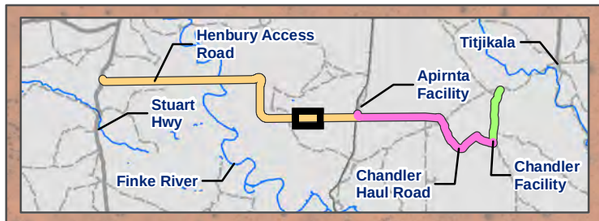
- No archaeological significance recorded
- Low to very low
- Low to moderate
- High to very high

Figure 10-5 (Sheet 6)
Archaeological material recorded in the area of the proposed Henbury Access Road

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller



WHAR 3 (OQ)

WHAR 3 (RS)

Lone Hill

Lone Hill - central point

Chiming Wedgebill BGS

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Document Path: C:\GIS_SSMaps\Chandler_Heritage_SMA_AccessTijikalaShown.mxd

N

200 100 0 200 Meters

Coordinate System:
GDA 1994 MGA Zone 53

Legend

Proposed development footprint

Henbury Access Road

Pastoral boundaries

Watercourse

Archaeological significance

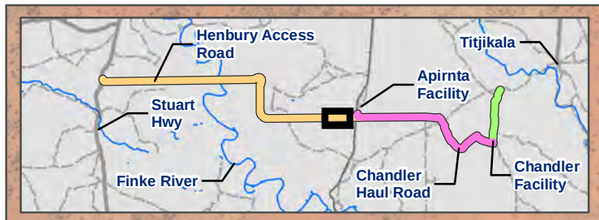
- No archaeological significance recorded
- Low to very low
- Low to moderate
- High to very high

Figure 10-5 (Sheet 7)
Archaeological material recorded in the area of the proposed Henbury Access Road

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use.
Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller



WHAR site 2

RAILWAY CREEK

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Document Path: C:\GIS_SS\Maps\Chandler_Heritage_SMA_AccessTijikalaShown.mxd

N

200 100 0 200 Meters

Coordinate System:
GDA 1994 MGA Zone 53

Legend

Proposed development footprint

Henbury Access Road

Pastoral boundaries

Watercourse

Archaeological significance

- No archaeological significance recorded
- Low to very low
- Low to moderate
- High to very high

Figure 10-5 (Sheet 8)
Archaeological material recorded in the area of the proposed Henbury Access Road

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller

10.3.6 Revised predictive model

A revised predictive model was developed based on the results of the field surveys.

Land systems with a high degree of archaeological sensitivity (that is, a high probability of containing archaeological material visible on the ground surface) include the Rumbalara, Chandlers and Gillen land systems. Land systems with a moderate degree of archaeological sensitivity (that is, a moderate probability of containing archaeological material visible on the ground surface) include the Singleton and Simpson land systems. Land systems with a low degree of archaeological sensitivity (that is, a low probability of containing archaeological material visible on the ground surface) include the Angas, Renners and Finke land systems.

At a finer-grained land form level, areas where there is a high probability of containing archaeological resources include:

- Areas in close proximity to two or more different landforms.
- Areas in the ranges, isolated hills and around/at rock outcrops where there are raw materials suitable for stone artefact manufacture.
- Areas with one kilometre of an ephemeral claypan.

Areas where there is a moderate probability of containing archaeological resources include:

- Areas of sandplains in relatively close proximity to ranges, rock outcrops and ephemeral water sources such as claypans. These areas also have the potential for sub-surface material to occur. Artefacts will be most visible on firmer substrates such as clays, hard compacted surfaces, areas with stony gibber, eroded scalds, and areas of disturbance along station tracks.
- Areas of dunefields up to 1 kilometre away from a water source, range or rock outcrop.
- Dunes outside of the Simpson land system. Artefacts will be most visible in deflated areas or on firmer substrates of adjoining landforms.
- Secondary terraces/levees banks and rocky surfaces along the Finke River, particularly where these occur nearby waterholes.
- Within 1 kilometre of an ephemeral creek.

Areas where there is low probability of containing archaeological resources include:

- Areas in the dunefields proper that are greater than 1 kilometre away from a water source, range or rock outcrop.
- In sandy rivers and major creek beds.
- On the river banks immediately adjacent to the Finke River.

- Areas of sandplains not in close proximity to ranges, rock outcrops or ephemeral water sources.

10.3.7 Assessments of significance

The historic item recorded during the field surveys (the matchbox tin) did not meet any of the heritage assessment criteria for significance.

Archaeological material recorded within the proposed development footprint was assessed for archaeological significance and individual assessments are provided in Appendix S. Materials were categorised as having:

- **Low and very low archaeological significance**. Typically consists of isolated finds, background scatters and low density artefact scatters. Individually, the diffuse, very low density background scatters and isolated finds have a limited potential to contribute substantially to our understanding of past occupation and land use patterns in the region. The types of raw materials and flaking technology evident at sites in this category are well represented elsewhere in the study area and wider region.
- **Moderate and moderate to high archaeological significance**. Typically consists of artefact scatters and may also include knapping floors and small stone quarries. These sites tend to contain a more diverse artefact assemblage than those in the preceding category. Some isolated finds are included in this category where the artefact is considered unusual, either in terms of raw material and/or manufacture and/or use. They may also occupy a particular part of the landscape not well represented elsewhere in the area. This material has some potential to contribute to debates around the timing and introduction of particular stone tool technologies (for example, grinding point industries), and can inform our understanding of raw material procurement and use strategies across the wider landscape. Sites of moderate to high significance typically include site complexes or larger sites with intra-site activity areas clearly evident in the form of at least two different site components
- **High or very high archaeological significance**. Typically includes large site complexes with moderate to high artefact densities, exhibiting a high degree of assemblage richness and diversity in terms of both stone raw materials and artefact types. Intra-site patterning is also apparent in the form of numerous and varied discrete activity areas. These sites usually contain three or more site components. These sites have considerable potential to contribute to our understanding at a broad level regarding the spatial distribution of sites in relation to resources, mobility strategies, raw material procurement and use strategies, trade, theoretical and methodological issues pertaining to landscape archaeology, as well as informing on the nature of specific stone artefact technologies, such as grinding technologies and manufacture of points. At a finer-grained level, detailed analyses of intra-site activity areas facilitate a greater in-depth understanding of how particular environmental niches were occupied.

The distribution of archaeological material of low and very low, moderate and moderate to high, and high or very high archaeological significance in the proposed development footprint is shown in Figure 10-2,

Figure 10-3,

Figure 10-4 and

Figure 10-5.

10.4 Assessment of risk during construction

The historic item recorded during the field surveys (the matchbox tin) was recorded outside of the proposed development footprint and would not be impacted during construction of the Proposal.

Some of the archaeological material located within the proposed development footprint would be directly impacted during construction of the Proposal. Additional archaeological material may be vulnerable to disturbance during construction due to its close proximity to the proposed development footprint. The impact on some sites is currently uncertain as final route selections (i.e. Henbury Access Road) have yet to be made and AAPA clearances for the Henbury and Chandler Haul Roads have yet to be obtained/received. Accordingly, the impacts below are provisional and would be reviewed once sacred site clearances and decisions regarding final road alignments have been made. It is possible that the roads may be aligned in order to avoid impacting upon archaeological material. A breakdown of the archaeological material that would be impacted is as follows:

- **Chandler Facility**. One site complex, four individual sites and three isolated finds would be directly impacted during construction of the proposed Chandler Facility (Tellus Site Complex, T9 Site, CS21, CS22, CS23, T18IF, CS20). In addition, two other site complexes (WT6 Bore Site Complex, CS18 and 19) and two individual sites (MVH3 Revised and CS17) may be vulnerable to disturbance during construction given their close proximity to the proposed Chandler Facility. Depending on the route of the Chandler Haul Road as it leaves the mine site, some other isolated finds may also be impacted (T25IF, T26IFa and T26IFb).
- **Apirnta Facility**. A background scatter (Railway background scatter) and three isolated finds (IFWP58 and IFWP59) would be directly impacted during construction of the proposed Apirnta Facility.
- **Chandler Haul Road**. Two sites would be directly impacted during construction of the proposed Chandler Haul Road (No.84 Bore Sites 2 and 3). In addition, one other site (No.84 Bore Site 1) and five isolated finds (IFWP88, 92, 93 and 94) may be vulnerable to disturbance during construction given their close proximity to the proposed haul road.
- **Henbury Access Road**. Two site complexes (White Rocky Hills Site Complex and WHAR 3 Site Complex), five individual sites (Finke River Scatter, Lone Hill, WHAR 2, Claypan 1 and Claypan 2), two background scatters (Stony Rises background scatter and Chiming Wedgebill background scatter) and five isolated finds (T15IF, T14IF and Duck Swamp IFa-c) would be directly impacted during construction of the proposed Henbury Access Road. The impact on

another site (WHAR 1), and three background scatters (Rocky Hills background scatters 1 and 2 and Bleak landscape background scatters) is currently uncertain, but at the very least this material is vulnerable to disturbance during construction given their close proximity to the proposed Maryvale Access Road. One isolated find (IFAMWP) may be impacted if the road deviates north along 15 Mile Creek to an alternative creek crossing.

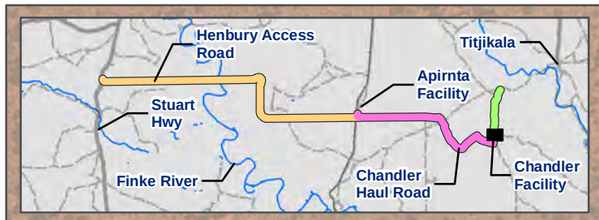
Archaeological material that would be directly impacted or potentially vulnerable to disturbance during construction of the Proposal is shown in Figure 10-6 and Figure 10-9.

The risk of damage to archaeological material from vibrations is considered to be very low. Nevertheless, specialist engineering advice may be sought prior to construction regarding the most appropriate blasting materials and methods, in order to minimise this risk. Monitoring of sites within a 1 kilometre radius of the blast site immediately after initial blasting would allow the identification of any adverse impacts and modification of the blasting program accordingly.

No scarred trees were located during the survey (which included areas with trees that were taller than 5 metres such as bloodwoods and desert oaks). Scarred trees are an uncommon occurrence in Central Australia. Therefore, the risk of damage to any unrecorded scarred trees would be low.

Mitigation and management measures that would be implemented to avoid or reduce impacts to cultural heritage resources during construction of the Proposal are discussed further in Section 10.7

.



CS23
MULGA CREEK
WT6 Bore Site Complex - AS
WT6 Bore Site Complex - Quarry
CS22
CS20
WT6 Bore Site Complex - KF
CS21
T18 IF Silcrete flake
MARYS CREEK
CS19
CS18a
CS18b
CS18c
CS18e
CS18d

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Document Path: C:\GIS_SS\Maps\Chandler_Heritage_SMA_AccessTitjikalaShown.mxd

N

75 37.5 0 75 Meters

Coordinate System:
GDA 1994 MGA Zone 53

Legend

Proposed development footprint

- Access road to Titjikala
- Chandler Facility
- Pastoral boundaries
- Cultural heritage exclusion zone
- Watercourse
- Existing track

Impact during construction

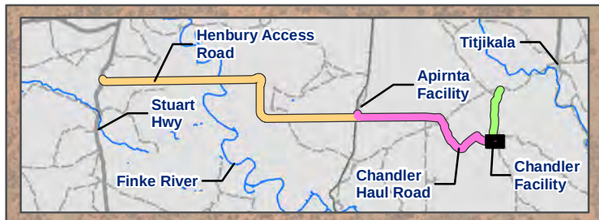
- Site directly impacted
- Site vulnerable to disturbance

Figure 10-6 (Sheet 1)
Archaeological material likely impacted during construction of the proposed Chandler Facility

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller



T9 site

OAK GULLY

MHV3 Revised

CS17

RIDEY GULLY

SNAKE GULLY

DINGO GULLY

ROO GULLY

Tellus Camp 3

Tellus Camp 2

Tellus Camp 1

HALFWAY CREEK

T26 IFa

T26 IFb

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Document Path: C:\GIS_SS\Maps\Chandler_Heritage_SMA_AccessTijikalaShown.mxd

N

100 50 0 100 Meters

Coordinate System:
GDA 1994 MGA Zone 53

Legend

Proposed development footprint

- Access road to Titjikala
- Chandler Haul Road
- Chandler Facility
- Pastoral boundaries
- Cultural heritage exclusion zone
- Watercourse
- Existing track

Impact during construction

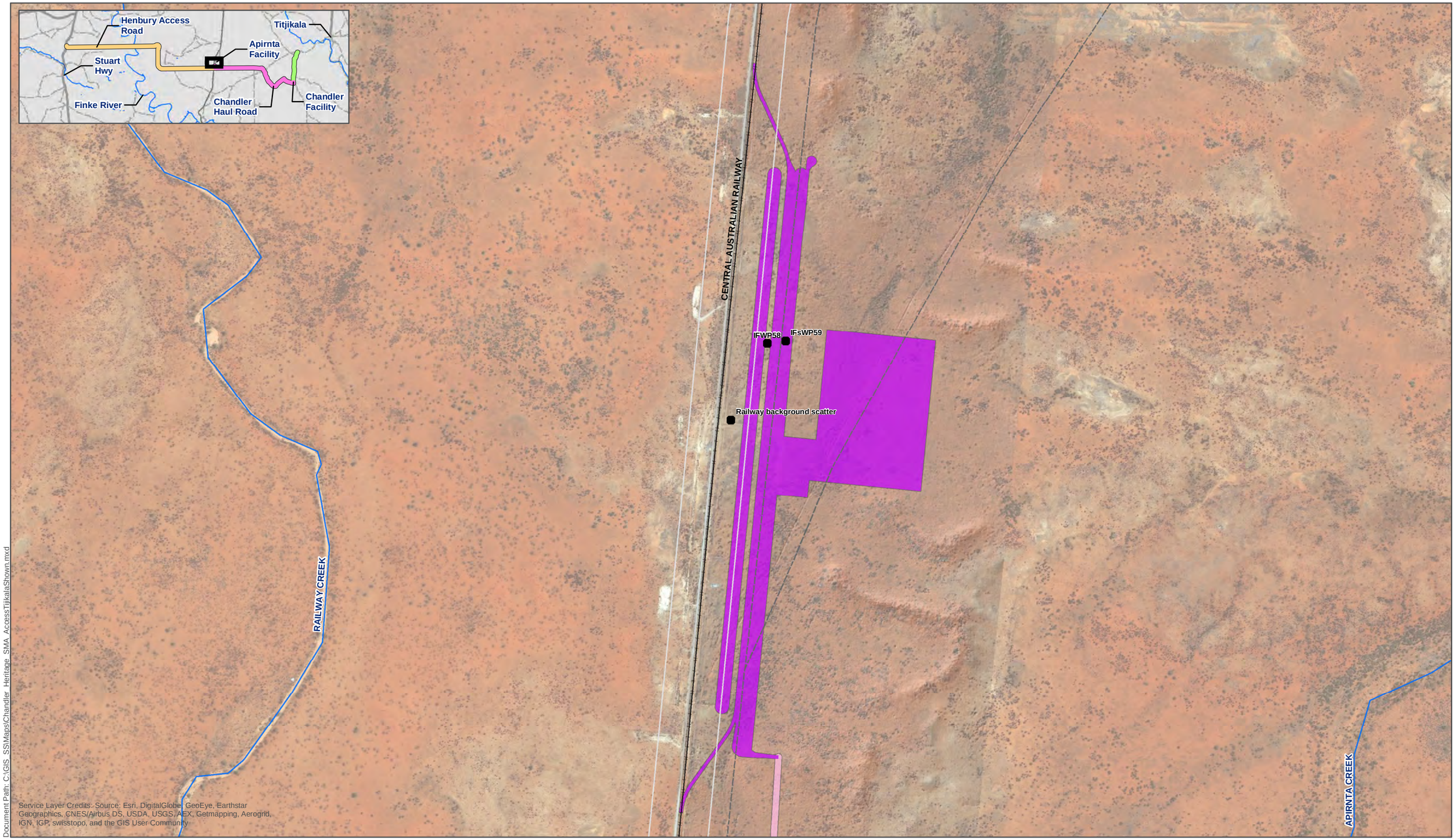
- Site directly impacted
- Site vulnerable to disturbance

Figure 10-6 (Sheet 2)
Archaeological material likely impacted during construction of the proposed Chandler Facility

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller



Document Path: C:\GIS_SSI\Maps\Chandler_Heritage_SMA_AccessTitjikalaShown.mxd

N

200 100 0 200 Meters

Coordinate System:
GDA 1994 MGA Zone 53

Legend

Proposed development footprint

- Chandler Haul Road
- Proposed development footprint - Apirnta Facility
- Pastoral boundaries
- Watercourse
- Existing track

Impact during construction

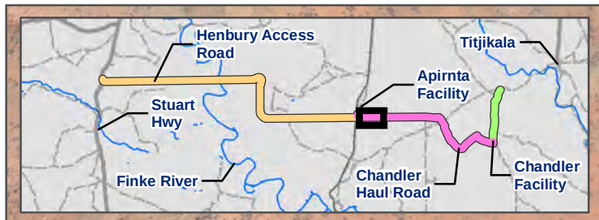
- Site directly impacted
- Site vulnerable to disturbance

Figure 10-7
Archaeological material likely impacted during construction of the proposed Apirnta Facility

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller



APIRNTA CREEK

Claypan 2 - central point

Claypan 1 - central point

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Document Path: C:\GIS_SS\Maps\Chandler_Heritage_SMA_AccessTijikalaShown.mxd

N

200 100 0 200 Meters

Coordinate System:
GDA 1994 MGA Zone 53

Legend

Proposed development footprint

- Chandler Haul Road
- Henbury Access Road

- Pastoral boundaries
- Watercourse
- Existing track

Impact during construction

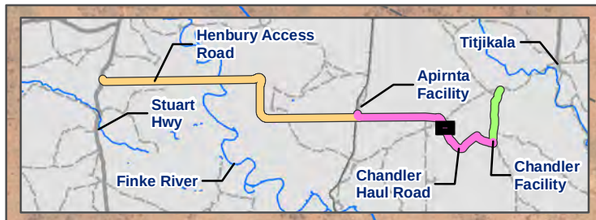
- Site directly impacted
- Site vulnerable to disturbance

Figure 10-8 (Sheet 1)
Archaeological material likely impacted during construction of the proposed Chandler Haul Road

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller



No.84 Bore Site 3

No.84 Bore Site 2

IF(WP94)

IF(WP93)

IF(WP92)

No.84 Bore Site 1

IFS(WP88)

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Document Path: C:\GIS_SSMaps\Chandler_Heritage_SMA_AccessTiijkalaShown.mxd

N

100 50 0 100 Meters

Coordinate System:
GDA 1994 MGA Zone 53

Legend

Proposed development footprint

Chandler Haul Road

Pastoral boundaries

Watercourse

Existing track

Impact during construction

Site directly impacted

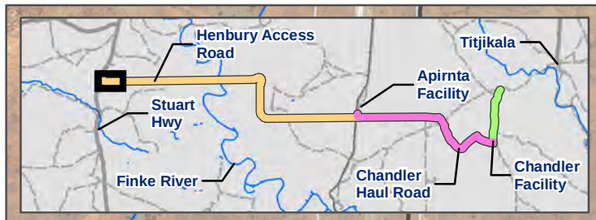
Site vulnerable to disturbance

Figure 10-8 (Sheet 3)
Archaeological material likely impacted during construction of the proposed Chandler Haul Road

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller



STUART HIGHWAY

Rocky Hills BG1

Rocky Hills BG2

Bleak landscape scatter

Stony Rises BGS - central point

Stony rises BGS - easternmost point

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Document Path: C:\GIS_SSMaps\Chandler_Heritage_SMA_AccessTitjikalaShown.mxd

N

200 100 0 200 Meters

Coordinate System:
GDA 1994 MGA Zone 53

Legend

Proposed development footprint

Henbury Access Road

Pastoral boundaries

Watercourse

Existing road

Impact during construction

Site directly impacted

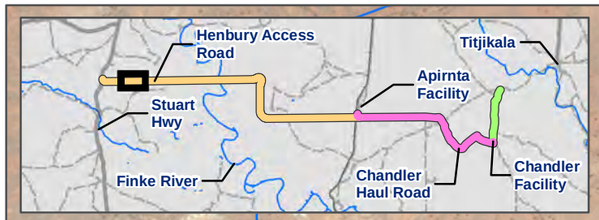
Site vulnerable to disturbance

Figure 10-9 (Sheet 1)
Archaeological material likely impacted during construction of the proposed Henbury Access Road

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use.
Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller



WHAR 1 - dune claypan site

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Document Path: C:\GIS_SSI\Maps\Chandler_Heritage_SMA_AccessTitjikalaShown.mxd

N

200 100 0 200 Meters

Coordinate System:
GDA 1994 MGA Zone 53

Legend

Proposed development footprint

Henbury Access Road

Pastoral boundaries

Watercourse

Impact during construction

Site directly impacted

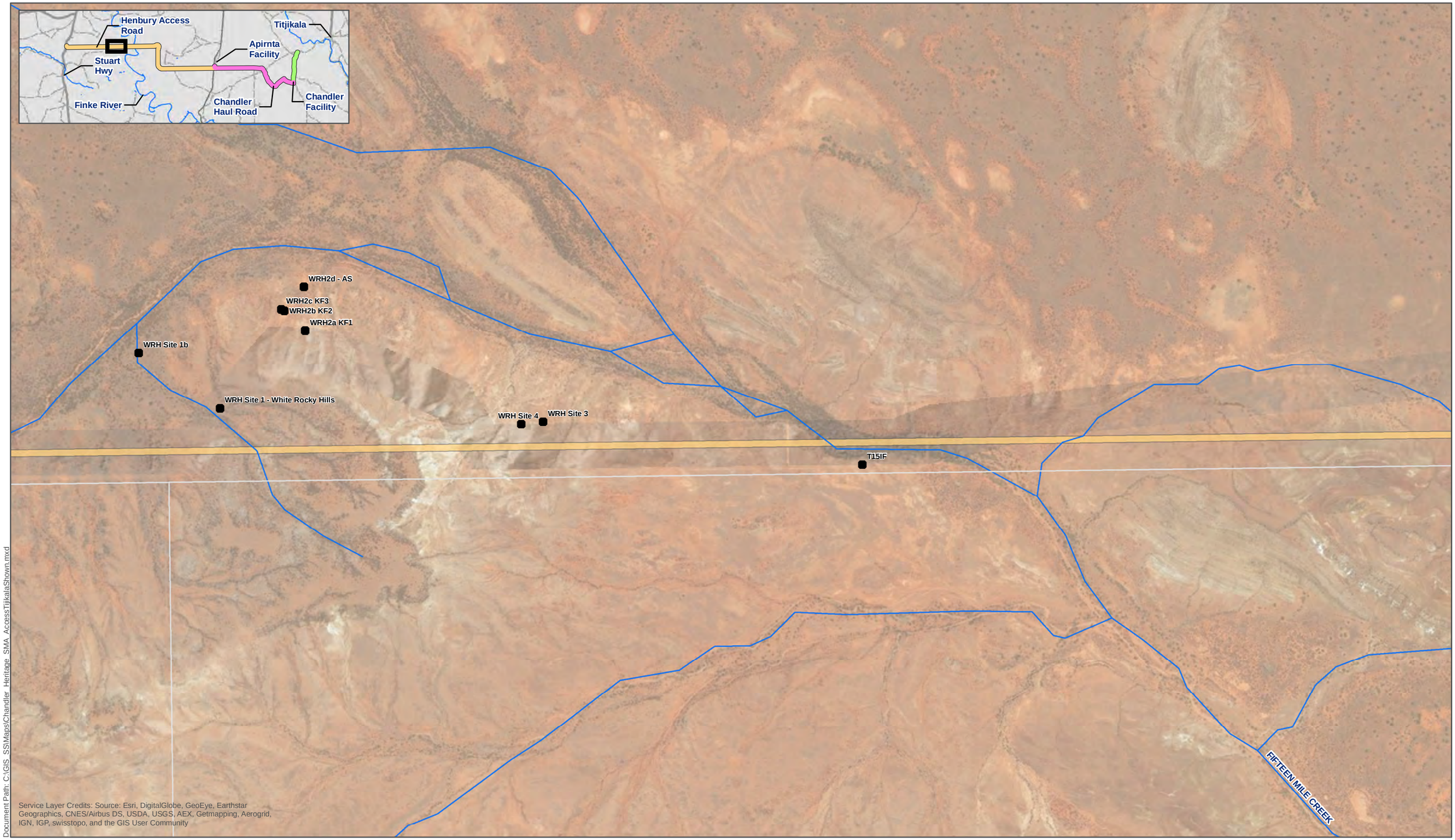
Site vulnerable to disturbance

Figure 10-9 (Sheet 2)
Archaeological material likely impacted
during construction of the proposed Henbury Access Road

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller



Document Path: C:\GIS_SSt\Maps\Chandler_Heritage_SMA_AccessTitjikalaShown.mxd

N

250 125 0 250 Meters

Coordinate System:
GDA 1994 MGA Zone 53

Legend

Proposed development footprint

Henbury Access Road

Pastoral boundaries

Watercourse

Impact during construction

Site directly impacted

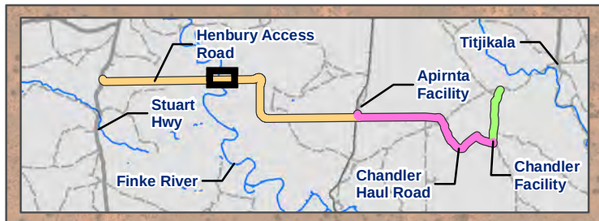
Site vulnerable to disturbance

Figure 10-9 (Sheet 3)
Archaeological material likely impacted
during construction of the proposed Henbury Access Road

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller



Finke River scatter

FINKE RIVER

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Document Path: C:\GIS_SS\Maps\Chandler_Heritage_SMA_AccessTijikalaShown.mxd

N

200 100 0 200 Meters

Coordinate System:
GDA 1994 MGA Zone 53

Legend

Proposed development footprint

Henbury Access Road

Pastoral boundaries

Watercourse

Impact during construction

Site directly impacted

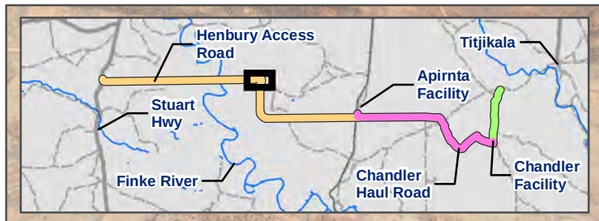
Site vulnerable to disturbance

Figure 10-9 (Sheet 4)
Archaeological material likely impacted
during construction of the proposed Henbury Access Road

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use.
Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller



T14IF

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Document Path: C:\GIS_SS\Maps\Chandler_Heritage_SMA_AccessTitjikalaShown.mxd

N

200 100 0 200 Meters

Coordinate System:
GDA 1994 MGA Zone 53

Legend

Proposed development footprint

Henbury Access Road

Pastoral boundaries

Watercourse

Impact during construction

Site directly impacted

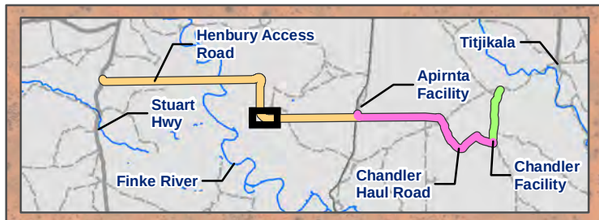
Site vulnerable to disturbance

Figure 10-9 (Sheet 5)
Archaeological material likely impacted
during construction of the proposed Henbury Access Road

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller



IFc Duck Swamp

IFb Duck Swamp

IFSa - Duck Swamp

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Document Path: C:\GIS_SSI\Maps\Chandler_Heritage_SMA_AccessTitjikalaShown.mxd

N

200 100 0 200 Meters

Coordinate System:
GDA 1994 MGA Zone 53

Legend

Proposed development footprint

Henbury Access Road

Pastoral boundaries

Watercourse

Impact during construction

Site directly impacted

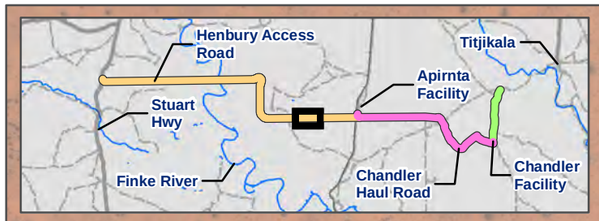
Site vulnerable to disturbance

Figure 10-9 (Sheet 6)
Archaeological material likely impacted during construction of the proposed Henbury Access Road

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller



WHAR 3 (OQ)

WHAR 3 (RS)

Lone Hill

Lone Hill - central point

Chiming Wedgebill BGS

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Document Path: C:\GIS_SSMaps\Chandler_Heritage_SMA_AccessTijikalaShown.mxd

N

200 100 0 200 Meters

Coordinate System:
GDA 1994 MGA Zone 53

Legend

Proposed development footprint

Henbury Access Road

Pastoral boundaries

Watercourse

Impact during construction

Site directly impacted

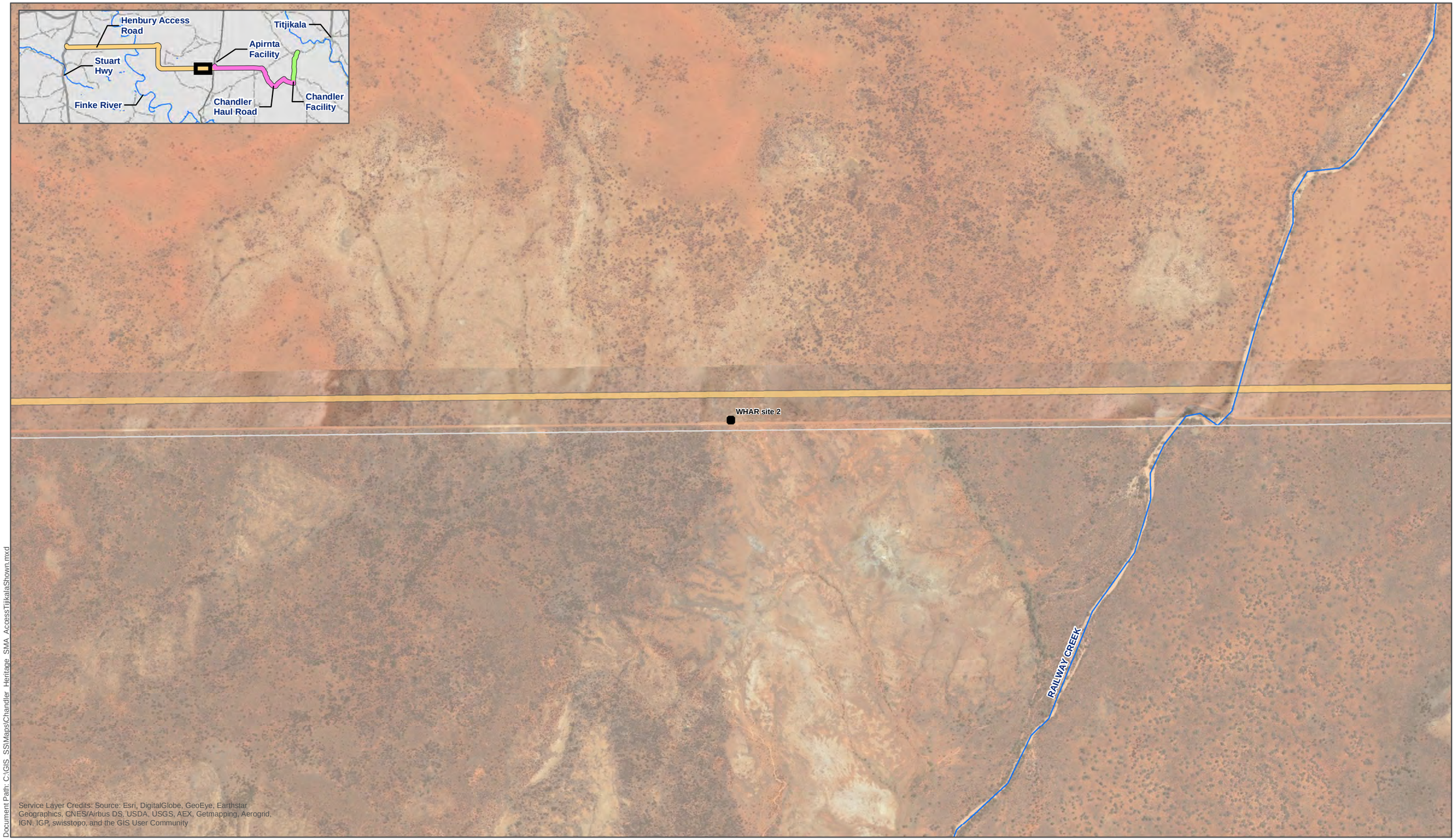
Site vulnerable to disturbance

Figure 10-9 (Sheet 7)
Archaeological material likely impacted during construction of the proposed Henbury Access Road

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller



Document Path: C:\GIS_SS\Maps\Chandler_Heritage_SMA_AccessTitjikalaShown.mxd

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

N

200 100 0 200 Meters

Coordinate System:
GDA 1994 MGA Zone 53

Legend

Proposed development footprint

Henbury Access Road

Pastoral boundaries

Watercourse

Impact during construction

Site directly impacted

Site vulnerable to disturbance

Figure 10-9 (Sheet 8)
Archaeological material likely impacted during construction of the proposed Henbury Access Road

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller

10.5 Assessment of risk during operation

The risk of adverse impacts to cultural heritage would be low during operation. Rather, works to conserve sites (e.g. to stem erosion, fencing) would have a positive impact on cultural heritage values in the area. Mitigation and management measures would be implemented to avoid or reduce impacts to cultural heritage resources during operation of the Proposal are discussed in Section 10.7.

10.6 Assessment of risk during closure and rehabilitation

The risk of adverse impacts to cultural heritage would be low during closure and rehabilitation. Mitigation and management measures would be implemented to avoid or reduce impacts to cultural heritage resources during closure and rehabilitation of the Proposal are discussed in Section 10.7.

10.7 Mitigation and monitoring

Mitigation and management measures proposed to avoid and/or minimise impacts on cultural heritage resources during construction, operation and/or decommissioning of the Proposal are listed in Table 7-11. These measures would be incorporated into the CEMP, OEMP and/or RCP for the Proposal. A draft Cultural Heritage Management Plan has also been prepared for the Proposal (refer to Appendix S).

Table 10-7 Mitigation and management measures (cultural heritage)

ID	Outcome	Mitigation/management measure	Timing
CH.1	Reduce the risk of inadvertently disturbing archaeological material during construction.	Undertake additional surveys of areas that would be impacted but have not yet been surveyed and which have a moderate to high probability of containing archaeological material (e.g. sections of the proposed Chandler Haul Road and eastern end of the proposed Henbury Access Road).	Pre-construction
CH.2	Preservation of areas of cultural sensitivity.	Clearly mark cultural heritage exclusion zones and ensure there is no intrusion into cultural heritage exclusion zones.	Pre-construction, construction, operation, and closure and rehabilitation
CH.3	Appropriate consent obtained to impact or potentially disturb archaeological material.	Ensure that appropriate consent is obtained for all sites that would be directly impacted or vulnerable to disturbance and require protective measures. Consent would be obtained from the NT Heritage Branch under section 72 of the NT *Heritage Act.*	Pre-construction
CH.4	Mitigation and management of archaeological material within and in the vicinity of the proposed development footprint.	Undertake additional mitigative works as part of conditions associated with gaining consent to impact or disturb particular archaeological material. For example, establishing “no-go” areas, undertaking mitigative recording of sites, relocating artefacts and establishing protective fencing (refer to Table 11a through Table 11d of Cultural Heritage Management Plan, Appendix S).	Pre-construction
CH.5	Mitigation and management of	Ensure that all cultural heritage resources within and in the vicinity of the proposed development	Pre-construction

ID	Outcome	Mitigation/management measure	Timing
	archaeological material within and in the vicinity of the proposed development footprint.	footprint are identified on general site maps and that no-go areas (i.e. sites or parts of sites to be protected, restricted areas) are also shown on all construction drawings.	
CH.6	Facilitate the ongoing management of cultural heritage resources.	Establish a database of cultural heritage resources within and in the vicinity of the proposed development footprint.	Pre-construction
CH.7	Mitigation and management of archaeological material within and in the vicinity of the proposed development footprint.	Establish a cultural awareness induction program for all contractors, employees and agents working on-site. Maps and drawings showing cultural heritage resources within the proposed development footprint would be provided to all contractors and employees working on-site.	Pre-construction and construction
CH.8	Mitigation and management of archaeological material within and in the vicinity of the proposed development footprint.	Implement protocols for the unanticipated discovery of archaeological material and skeletal remains as per the Cultural Heritage Management Plan at Appendix S.	Pre-construction, Construction
CH.9	Mitigation and management of archaeological material within and in the vicinity of the proposed development footprint.	Ensure that sites identified as vulnerable to disturbance are subject to regular monitoring at monthly intervals. Implement management measures, if necessary (e.g. implementing works to stem erosion, reviewing the efficacy of site protection measures including fencing, the cultural heritage induction program and mapping).	Construction
CH.10	Mitigation and management of archaeological material within and in the vicinity of the proposed development footprint.	Ensure that sites identified as vulnerable to disturbance are subject to monitoring on an annual basis. Implement conservation and management measures for other sites as appropriate (e.g. detailed recording, conservation works).	Operation
CH.11	Mitigation and management of archaeological material within and in the vicinity of the proposed development footprint.	Ensure any new areas subject to ground disturbance in the future are assessed and surveyed in accordance with the predictive models and appropriate actions taken in relation to the NT *Heritage Act*.	Operation
CH.12	Mitigation and management of archaeological material within and in the vicinity of the proposed development footprint.	Ensure that the condition of all sites are recorded one last time. Remove protective fencing once all infrastructure had been dismantled and removed from site and other rehabilitation works are complete. Forward all data pertaining to each site including site records, documentation (e.g. results of monitoring), photographs, records of action taken, etc. are forwarded to the NT Heritage Branch.	Decommissioning

10.8 Summary of risk assessment

A summary of the risk assessment undertaken for historic and cultural heritage during construction, operation, and closure and rehabilitation of the Proposal is provided in Table 10-8.

Table 10-8 Summary of risk assessment (historic and cultural heritage)

Hazard	Pre-mitigated risk			Post-mitigated risks			Risk outcome
	Likelihood	Consequence	Risk ranking	Likelihood	Consequence	Risk ranking	
Physical disturbance to known sites	Likely	Moderate	High	Eliminated	Moderate	Eliminated	Risk reduced
Physical disturbance to unknown sites	Remote	Moderate	Low	Remote	Moderate	Low	Risk same
Loss of trees (>5m) of value to traditional owners	Almost certain	Moderate	High	Almost certain	Minor	High	Risk reduced
Loss of scarred trees	Unlikely	Moderate	Medium	Remote	Moderate	Low	Risk reduced
Disturbance of sensitive land at the decline entry	Eliminated	Minor	Eliminated	Eliminated	Minor	Eliminated	Risk same

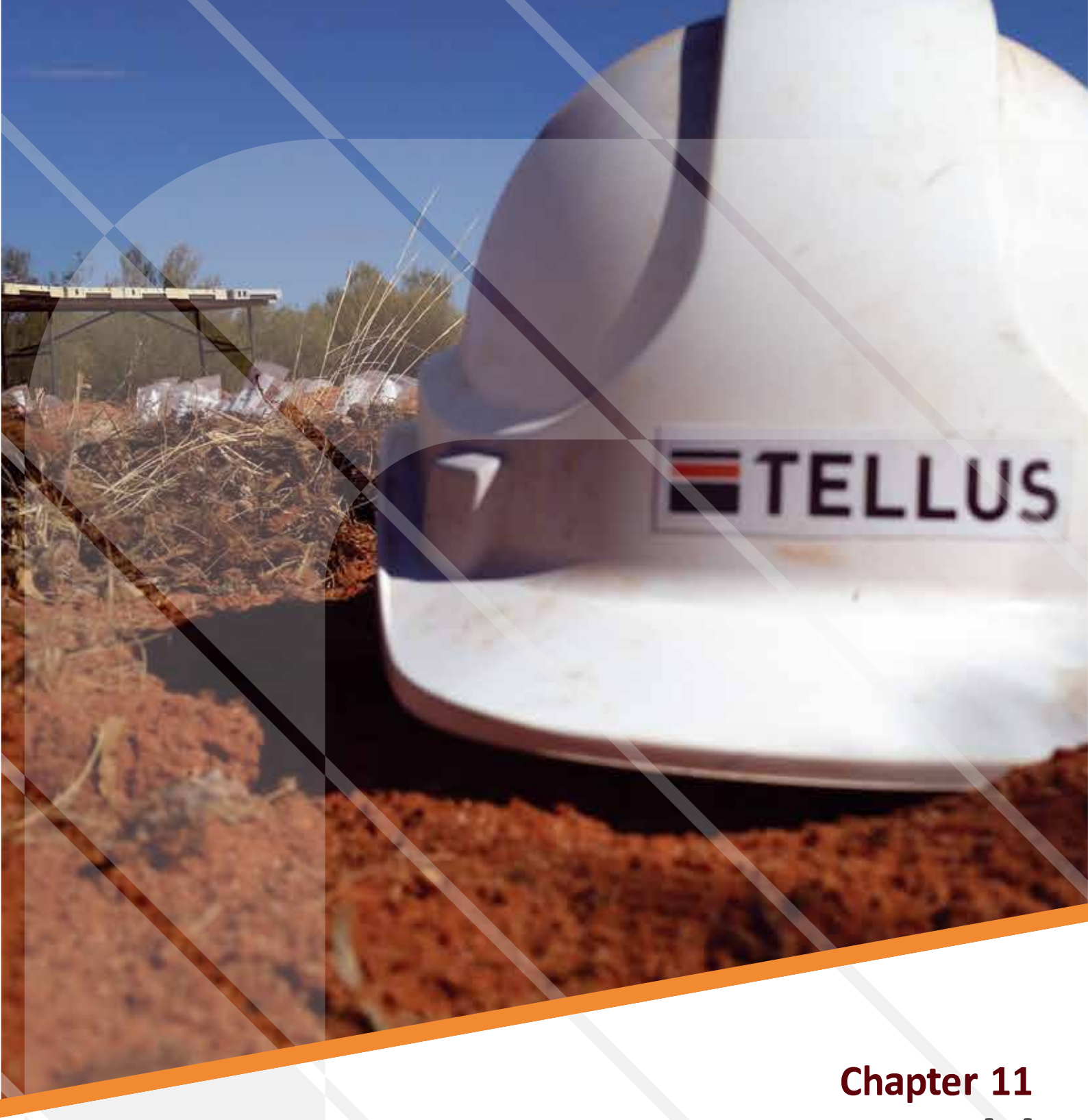
10.9 Conclusion

No historic items would be impacted during construction or operation of the Proposal. With regards to archaeological material, at least three site complexes, 11 individual sites, three background scatters and 11 isolated finds would be directly impacted during the construction of the Proposal. In addition, at least two site complexes, four individual sites, three background scatters and six isolated finds may be vulnerable to disturbance during construction given their close proximity to the proposed development footprint.

Additional surveys of areas that would be impacted but have not yet been surveyed and which have a moderate to high probability of containing archaeological material (e.g. sections of the proposed Chandler Haul Road and eastern end of the proposed Henbury Access Road) would be undertaken prior to construction.

Appropriate consent would be obtained for all sites that would be directly impacted or vulnerable to disturbance (and requiring protective measures). Consent would be obtained from the NT Heritage Branch under Section 72 of the NT Heritage Act. Additional mitigation and management measures to preserve cultural heritage values would be included in a Cultural Heritage Management Plan as part of the CEMP, OEMP and/or RCP for the Proposal.

The risk of adverse impacts to cultural heritage would be low during operation and decommissioning of the Proposal.



Chapter 11

Human Health and Safety

This page has been left intentionally blank

11 HUMAN HEALTH

11.1 Introduction

This chapter describes the existing risks to human health and safety within the proposed development footprint and vicinity of the Proposal. The potential hazards and associated risks to human health and safety are assessed and mitigation and management measures are identified to avoid or reduce the potential risks to human health and safety during construction, operation and closure and rehabilitation of the Proposal.

The primary risk to human health and safety would be the handling and storage of hazardous materials. A list of hazardous materials that would be used on-site is provided in Appendix F.

The assessment has been prepared in accordance with the Terms of Reference (refer to Appendix A).

11.2 Methodology

A human health and safety hazard and risk assessment was prepared to show that residual risk levels would be acceptable in relation to humans and the surrounding environment, and that potential risks would be appropriately managed. The assessment involved:

- Identifying potential hazards during construction, operation, and closure and rehabilitation of the Proposal through a series of risk workshops.
- Assessing the risks associated with the potential hazards by determining the probability (likelihood) and consequence (effects) of hazardous events for humans, the surrounding land uses and the environment during construction, operation, and closure and rehabilitation of the Proposal.
- Identifying approaches (mitigation and management measures) to avoid or reduce the potential hazards (and associated risks).

The risk assessment determined the Proposal is likely to require notification under the NT *Work Health Safety Act* as a Major Hazard Facility. The NT Work Health and Safety (National Uniform Legislation) Regulations (Work Health Safety (WHS) Regulations) 536, 537 and 547 are triggered because the Proposal may exceed 10 % of the threshold quantities of hazardous chemicals listed within Schedule 15 of the WHS Regulations.

The NT *Work Health Safety Act* and WHS Regulations identify requirements for preparing and executing emergency plans, storage and handling systems, health monitoring during construction and operation.

11.3 Existing environment

The proposed Chandler Facility and the Chandler Haul Road would be located within Maryvale Station (NT Portion 810). The proposed Apirnta Facility, Henbury Access Road and a portion of the Chandler Haul Road would be located within Henbury Station (NT Portion 657), to the west of the

proposed Chandler Facility (refer to Chapter 1 and Figure 1-1). Land within Maryvale Station and Henbury Station is pastoral lease land governed under the NT *Pastoral Land Act.* As such, land within Maryvale Station and Henbury Station is used for pastoral activities (specifically for grazing cattle). The use of hazardous materials is primarily limited to diesel that is used to fuel station vehicles.

The Central Australian Railway is located approximately 30 kilometres to the west of the proposed Chandler Facility. The proposed Apirnta Facility would be located adjacent to the Central Australian Railway. The Stuart Highway is located approximately 60 kilometres to the west of the proposed Apirnta Facility and 90 kilometres to the west of the proposed Chandler Facility (refer to Chapter 1 and Figure 1-1). Commercial dangerous goods, including hydrocarbons, are regularly transported by train between Adelaide and Darwin on the Central Australian Railway and by truck along the Stuart Highway.

11.4 Assessment of risk during construction, operation and closure and rehabilitation

This section presents the potential hazards and associated risks to human health and safety during construction, operation and closure and rehabilitation of the Proposal. Mitigation measures to avoid or reduce these impacts are discussed in Section 11.5.

The primary hazardous materials that would be store on-site are listed wastes and include dangerous chemicals and hydrocarbons (refer to Appendix F). The hazardous chemicals that require special storage and handling would be managed at the proposed Apirnta Facility before being transported for permanent isolation at the proposed Chandler Facility.

Other hazardous materials would be used on-site for general construction, operation and closure and rehabilitation activities. Diesel would be required to fuel the mining and vehicle fleet and the generators at the borefield. At a mining rate of approximately 760,000 tonnes per annum, the estimated diesel requirement would be five mega litres per annum. To achieve this, there would be three 10,000 litre deliveries per week by triple carriage semitrailers. Fuel would be stored in self bunded 30,000 litre tanks within a bunded hardstand zone within the mine infrastructure area (refer to Figure 3-3).

Oils and lubricants would be used in the vehicle fleet and within the process plant with small amounts also used to service equipment such as generators and pumps. Oils and lubricants would be delivered by truck. They would be stored within the same location as the self bunded diesel/fuel tanks but separated, where appropriate (refer to Figure 3-3).

Explosives would be used primarily for blasting of the proposed decline portal and tunnel. Explosives use on-site would likely be expected to peak during construction at 2,000 tonnes per annum. It is not expected that explosives would be used during operation or closure and rehabilitation of the Proposal. Explosives would be stored in a separate self bunded area within the mine infrastructure area (refer to Figure 3-3).

Other hazardous materials used on-site (e.g. kerosene, welding gases, battery storages) would be stored appropriately on-site in accordance with industry regulations, codes and standards.

Potential hazards during construction, operation, and closure and rehabilitation of the Proposal are listed in Table 11-1.

Table 11-1 Potential hazards and associated risks during all phases of the Proposal

Potential hazard/risk scenario	Cause	Consequence
Exposure from dry waste	Significant volumes of waste, some hazardous, enters work sites and reacts with other materials	Generation of toxic gases
Exposure from wet waste	Significant volumes of waste, some hazardous, enters work sites and reacts with other materials	Generation of toxic gases
Exposure from fuel spills	Accidental spill	Personal health issues
Exposure from waste materials and surface traffic fumes	Waste emplacement and vehicles generates odour and particulates	Personal health issues
Vehicle collision with pedestrians (above and below ground)	Vehicle movements in the vicinity of personnel	Personal injury
Vehicle accidents (above and below ground)	Vehicle movements in the vicinity of other vehicles	Personal injury
Exposure from mine gas extraction	Release of natural underground gases	Personal health issues
Ventilation failure	Power failure	Personal health issues including asphyxiation
Underground vehicle fire	Accident or operator error	A fire develops and personal injury/death results
Underground vehicle exhaust exposure	Operation of plant	Personal health issues
Heat stress (above and below ground)	Natural/seasonal weather conditions	Personal health issues
Construction accidents surface - infrastructure	Failure of machine guarding/working in close proximity to rotating and moving equipment	Personal injury
Construction accidents - underground infrastructure	Failure to observe underground traffic signage	Personal injury
Uncontrolled gas release - underground pressure release	Accident or operator error	Personal health issues
Uncontrolled gas release – underground ignition	Stockpiling of incoming waste material for extended periods of time. Failure of aeration system for other reasons	Anaerobic decomposition takes place producing/releasing dangerous gases
Uncontrolled gas release – underground asphyxiation	Access to mine shafts and decline	Possible asphyxiation due to atmospheric conditions within a confined space
Waste stability with heat	Waste materials could spontaneously combust with elevated air temperatures	Generation of fire and release of toxic gases
Bites and stings	Local insects	Personal health issues
Drugs and alcohol abuse	Breach of drug and alcohol policy	Personal health issues

Potential hazard/risk scenario	Cause	Consequence
Strata and ground stability	Spontaneous rock collapse	Personal injury/death results
Mine and drill blast	Use of explosives	Personal injury including loss of hearing
Ignition of flammable materials	Ignition of flammable materials stored on-site e.g. waste paper, cardboard, plastics etc.	A fire develops and personal injury/death
Fall from height	Person working a height falls	Personal injury
Electrical incident	Exposure to damaged electrical equipment or operator error.	Personal injury
Exposure from radiation	Exposure to NORM	Personal health issues
Windblown materials	Exposure to particulate matter from RoM stockpiles including salt	Personal health issues.

11.5 Mitigation and monitoring

Mitigation and management measures proposed to minimise the potential impacts on human health during construction, operation, and closure and rehabilitation of the Proposal are listed in Table 11-2. These measures would be incorporated into the CEMP, OEMP and/or RCP for the Proposal. A draft Emergency Response Management Plan has been prepared and is included in Appendix T.

As discussed in Chapter 3, the proposed Chandler Facility qualifies as a major hazard facility under the Work Health and Safety (National Uniform Legislation) Regulations. As such, the facility requires the preparation of a Safety Case to demonstrate that it can be operated safely and within the requirements of the Work Health and Safety (National Uniform Legislation) Regulations. An outline Safety Case is included in Appendix X.

The proponent currently maintains and continuously improves an Environmental Management System that complies with the requirements of the International Standard *ISO 14001:2015 Environmental Management Systems*, International Standard *ISO 9001:2015 Quality Management Systems*, and Australian and New Zealand Standard *AS/NZS 4801:2001 Occupational Health and Safety Management System*. Once all necessary approvals have been obtained for the Proposal, the proponent would update the Environmental Management System with management plans and procedures relevant to the construction, operation and closure and rehabilitation of the Proposal.

Table 11-2 Mitigation and management measures (human health and safety)

ID	Outcome	Mitigation/management measure	Timing
HS.1	Minimisation of potential impacts on human health and the environment through responsible storage and handling of hazardous materials.	Finalise Safety Case for a Major Hazard Facility in accordance with the NT *Work Health Safety Act* and the NT WHS Regulations 536, 537 and 547 administered by NT WorkSafe and the Australian Dangerous Goods Code 2007.	Detailed design

ID	Outcome	Mitigation/management measure	Timing
HS.2	Minimisation of potential impacts on human health and the environment.	Finalise Emergency Response Management Plan.	Pre-construction
HS.3	Minimisation of potential impacts on human health and the environment.	Update Environmental Management System with management plans and procedures relevant to the construction, operation and closure and rehabilitation of the Proposal.	Pre-construction, construction, operation, closure and rehabilitation
HS.4	Minimisation of potential impacts on human health and the environment through responsible transportation, storage and handling of hazardous materials.	• Transport, store and handle hazardous materials in accordance with industry regulations, codes and standards (e.g. *Work Health and Safety (National Uniform Legislation)* Act and the NT WHS Regulations • Adhere to Chandler Safety Case. • Adhere to Chandler Waste Acceptance Procedure (WAP), Waste Acceptance Criteria (WAC) and Waste Zoning Guide (WZG). • Adhere to Emergency Response Management Plan.	Construction, operation, closure and rehabilitation
HS.5	Minimisation of potential impacts on human health and the environment through responsible transportation of hazardous materials.	• Transport hydrocarbons in compliance with the Australian Dangerous Goods Code 2007. • Ensure all vehicles are registered and carry appropriate equipment to respond to a spill, including personal protective equipment (PPE).	Construction, operation, closure and rehabilitation
HS.6	Minimisation of potential impacts on human health and the environment through responsible handling of hazardous materials.	Ensure personnel are trained in the appropriate handling of hazardous materials and in clean-up procedures in the event of a spill.	Construction, operation, closure and rehabilitation
HS.7	Minimisation of potential impacts on human health and the environment through responsible storage of hazardous materials.	Store diesel in 30,000 litre self-bunded tanks manufactured in compliance with Australian Standard (AS)1692 (Steel Tanks for Flammable and Combustible Liquids) and installed in compliance with AS1940 (The Storage and Handling of Flammable and Combustible Liquids).	Construction, operation
HS.8	Minimisation of potential impacts on human health and the environment through responsible storage of hazardous materials.	• Store lubricating oil in bulk containers inside a bunded area with spill protection and recovery kits. • Ensure waste hydrocarbons are stored in tanks inside a bunded area and held for collection by an appropriately licensed contractor for reprocessing and recycling.	Construction, operation
HS.9	Minimisation of potential impacts on human health and the environment through responsible storage and handling of hazardous materials.	Store ammonium nitrate in a dedicated building and in accordance applicable regulations, codes and standards. Ensure that ammonium nitrate is handled by appropriately trained personnel.	Construction, operation

ID	Outcome	Mitigation/management measure	Timing
HS.10	Minimisation of potential impacts on human health and the environment through appropriate clean-up of spills in accordance with Emergency Response Management Plan.	In the event of a spill of hazardous material, implement the strategies outlined in the Emergency Response Management Plan. These strategies would include (but would not be limited to): • Isolating and containing spill using spill kit. • Evacuating area if potential danger exists. • Notifying Environmental Manager. Provide location, extent, substance type, quantity, environments impacted (e.g. soils, surface watercourses, groundwater) and spill kit contents used. • Using spill kit to remove the contamination source or, where relevant, excavate and appropriately dispose of contaminated sediments. • Commencing investigation into soil, surface and/or groundwater impacts from the spill. Detail spill quantity, determine extent and significance of impact to human health and/or environment (including upstream/control samples, as required). • Providing DPIR with Section 29 Notification and NT EPA with Section 14 Incident Report Form within 24 hours of incident occurring if the incident caused or is threatening or may threaten to cause pollution resulting in minor or serious environmental harm. • Ensuring spill kits are located at all hazardous material storage locations. Spill kits would be available to be relocated to specific areas in accordance with scopes of work.	Construction, operation, closure and rehabilitation
HS.11	Minimisation of potential impacts on human health and safety (general)	Establish emergency medical safety points containing eye flush/body flush stations and first aid kits at easily identifiable key locations above and underground.	Construction, operation, closure and rehabilitation
HS.12	Minimisation of potential impacts on human health and safety (exposure from fuel spills)	• Adhere to WAP and WAC. • Wear appropriate PPE.	Construction, operation, closure and rehabilitation
HS.13	Minimisation of potential impacts on human health and safety (pedestrian and vehicle interactions)	• Develop Traffic Management Plan. The plan would include standard traffic rules, signage etc. It would also include collision avoidance system (refer to Chapter 15) • Mark designated pedestrian areas. • Promote driver competency through training programs, as necessary.	Construction, operation, closure and rehabilitation
HS.14	Minimisation of potential impacts on human health and safety (exposure from mine gas extraction)	• Wear and maintain correct PPE (including breathing apparatus). • Aerate decline and shafts.	Construction and operation

ID	Outcome	Mitigation/management measure	Timing
		• Undertake gas monitoring.	
HS.15	Minimisation of potential impacts on human health and safety (ventilation failure)	• Ensure there is a back-up supply of power. • Wear and maintain correct PPE (including breathing apparatus).	Construction, operation, closure and rehabilitation
HS.16	Minimisation of potential impacts on human health and safety (underground vehicle fire)	• Establish underground escape routes and isolation zones. • Ensure fire extinguishers and suppression systems are installed.	Construction, operation, closure and rehabilitation
HS.17	Minimisation of potential impacts on human health and safety (underground vehicle exhaust exposure)	• Consider use of electrical vehicles underground. • Wear and maintain correct PPE (including breathing apparatus, as appropriate). • Aerate decline and shafts. • Undertake gas monitoring.	Construction, operation, closure and rehabilitation
HS.18	Minimisation of potential impacts on human health and safety (heat stress - above and below ground)	• Remain hydrated and have a sufficient supply of water. • Wear and maintain correct PPE.	Construction, operation, closure and rehabilitation
HS.19	Minimisation of potential impacts on human health and safety (construction accidents)	• Install machine guarding. • Adhere to operational and maintenance procedures. • Ensure operator competency through training, as necessary.	Construction
HS.20	Minimisation of potential impacts on human health and the environment (underground ignition).	• Adhere to Chandler WZG. • Undertake weekly gas monitoring in storage areas. • Ensure fire extinguishers and suppression systems are installed. • Install aeration system to maintain ventilation and restrict temperature rise.	Operation
HS.21	Minimisation of potential impacts on human health and safety (bites and stings)	• Wear appropriate PPE. • Use insect repellent.	Construction, operation, closure and rehabilitation
HS.22	Minimisation of potential impacts on human health and safety (drugs and alcohol abuse)	• Develop Drug and Alcohol Management Plan. • Implement daily testing for drugs and blood alcohol levels.	Construction, operation, closure and rehabilitation
HS.23	Minimisation of potential impacts on human health and safety (strata and ground stability)	• Correct design of room and pillar in the salt formation. • Wear and maintain correct PPE (including two-way radio).	Construction, operation, closure and rehabilitation

ID	Outcome	Mitigation/management measure	Timing
HS.24	Minimisation of potential impacts on human health and safety (mine and drill blasting)	• Ensure there is an adequate separation zone whilst blasting occurs. • Wear hearing protection. • Wear and maintain correct PPE.	Construction and operation
HS.25	Minimisation of potential impacts on human health and the environment (ignition of flammable materials).	• Adhere to Chandler WZG and Dangerous Goods Regulations. • Ensure fire extinguishers and suppression systems are installed.	Construction, operation, closure and rehabilitation
HS.26	Minimisation of potential impacts on human health and safety (fall from height)	• Ensure operator competency for working at heights. • Implement work at heights procedures. • Use suitable work at heights equipment e.g. fall protection.	Construction, operation, closure and rehabilitation
HS.27	Minimisation of potential impacts on human health and safety (electrical incident)	• Design and maintain all electrical systems as per legislative requirements. • Install physical protection (cabinets, bollards etc.) around high risk electrical installations.	Construction, operation, closure and rehabilitation
HS.28	Minimisation of potential impacts on human health and safety (exposure from radiation)	• Adhere to WAP and WAC. • Wear and maintain correct PPE.	Operation
HS.29	Minimisation of potential impacts on human health and safety (windblown materials)	• Factor local wind directions during placement of stockpiles. • Consider vegetation cover for long term stockpiles.	Construction and operation
HS.30	Minimisation of potential impacts on human health and safety (confined space)	• Ensure operational procedures are adhered to including those listed in the Air Quality Management Plan. • Ensure workers obtain confined space permits. Ensure operator competency in confined space entry. • Use breathing apparatus, where necessary. • Aerate decline and shafts. • Undertake gas monitoring.	Construction, operation, closure and rehabilitation

11.6 Summary of risk assessment

A summary of the risk assessment undertaken for human health and safety during construction, operation and closure and rehabilitation of the Proposal is provided in Table 11-3.

Table 11-3 Summary of risk assessment (human health and safety)

Hazard	Pre-mitigated risk			Post-mitigated risks			Risk outcome
	Likelihood	Consequence	Risk ranking	Likelihood	Consequence	Risk ranking	
Exposure from dry waste	Unlikely	Moderate	Medium	Remote	Moderate	Low	Risk reduced
Exposure from wet waste	Unlikely	Moderate	Medium	Remote	Moderate	Low	Risk reduced
Exposure from fuel spills	Remote	Minor	Low	Remote	Minor	Low	Risk same
Exposure from surface traffic fumes	Remote	Minor	Low	Remote	Minor	Low	Risk same
Vehicle collision with pedestrians (above and below ground)	Likely	Catastrophic	Extreme	Unlikely	Catastrophic	High	Risk reduced
Vehicle accidents (above and below ground)	Likely	Catastrophic	Extreme	Unlikely	Catastrophic	High	Risk reduced
Exposure from mine gas extraction	Almost certain	Minor	High	Unlikely	Minor	Low	Risk reduced
Ventilation failure	Likely	Moderate	High	Unlikely	Moderate	Medium	Risk reduced
Underground vehicle fire	Likely	Major	High	Unlikely	Major	Medium	Risk reduced
Underground vehicle exhaust exposure	Almost certain	Major	Extreme	Remote	Major	Medium	Risk reduced
Heat stress above and below ground	Almost certain	Moderate	High	Unlikely	Moderate	Medium	Risk reduced
Construction accidents - surface infrastructure	Possible	Catastrophic	High	Remote	Catastrophic	Medium	Risk reduced
Construction accidents - underground infrastructure	Possible	Catastrophic	High	Remote	Catastrophic	Medium	Risk reduced
Uncontrolled gas release - underground pressure release	Unlikely	Catastrophic	High	Remote	Catastrophic	Medium	Risk reduced
Uncontrolled gas release - underground ignition	Unlikely	Catastrophic	High	Remote	Catastrophic	Medium	Risk reduced
Uncontrolled gas release - underground asphyxiation	Unlikely	Catastrophic	High	Remote	Catastrophic	Medium	Risk reduced
Waste stability with heat	Unlikely	Major	Medium	Eliminated	Major	Eliminated	Risk reduced
Bites / stings	Almost certain	Catastrophic	Extreme	Unlikely	Moderate	Medium	Risk reduced
Drugs and alcohol abuse	Almost certain	Major	Extreme	Remote	Major	Medium	Risk reduced
Strata / ground stability	Unlikely	Catastrophic	High	Remote	Catastrophic	Medium	Risk reduced

Hazard	Pre-mitigated risk			Post-mitigated risks			Risk outcome
	Likelihood	Consequence	Risk ranking	Likelihood	Consequence	Risk ranking	
Mine drill and blasting	Eliminated	Insignificant	Eliminated	Eliminated	Insignificant	Eliminated	Risk same
Ignition of flammable materials	Possible	Major	High	Unlikely	Major	Medium	Risk reduced
Fall from height	Possible	Catastrophic	High	Unlikely	Catastrophic	High	Risk reduced
Electrical incident	Possible	Major	High	Unlikely	Major	Medium	Risk reduced
Exposure from Naturally Occurring Radioactive Material (NORM)	Unlikely	Major	Medium	Eliminated	Major	Eliminated	Risk reduced

11.7 Conclusion

The assessment of hazards and risks on human health and safety was undertaken through the mechanism of risk workshops. The outcome of the risk workshops was the identification of potential hazards and risks during the construction, operation, and closure and rehabilitation of the Proposal.

They key risks on human health and safety without mitigation or management measures in place were identified as being the transport, handling and storage of hazardous wastes, fire and working underground. By following the procedures outlined in the various applicable industry regulations, codes and standards, as well implementing the mitigation and monitoring measures outlined in Table 11-2, the residual risks on human health and safety are reduced and considered manageable through each phase of the Proposal.



Chapter 12

Economic and Social

This page has been left intentionally blank

12 ECONOMIC AND SOCIAL

12.1 Introduction

This chapter assesses the likely economic and social impacts during construction, operation, and closure and rehabilitation of the Proposal. This chapter draws on a comprehensive economic and social impact assessment which is included as Appendix U. It also draws on the extensive community and government consultation undertaken during the development of the Proposal. This chapter describes the existing economic and social environment within the local region and the NT. The potential economic and social impacts are assessed and mitigation and management measures are identified to reduce potential impacts.

The assessment has been prepared with reference to the *Guidelines for the Preparation of an Economic and Social Impact Assessment* (NT EPA 2013) and with reference to various international guidelines developed by the International Association for Impact Assessment and the International Association for Public Participation. It has also been prepared in accordance with the Terms of Reference (refer to Appendix A).

12.2 Methodology

This section describes the methodology for the economic and social impact assessment. Further detail is provided in Appendix U.

12.2.1 Economic impact assessment

The methodology for the economic impact assessment included a review of publicly available economic data and economic modelling to estimate the economic impact from the construction and operation of the Proposal.

Data sources

Data regarding the description of the economy and key economic variables was obtained from publicly available sources. The primary source of data was from the Australian Bureau of Statistics (ABS) including the 2011 Census.

Data was collected for the following statistical areas which are referred to as:

- Local region – the Sandover Plenty SA2 area as defined by the ABS in addition to the Alice Springs Local Government Area.
- NT – as defined by the boundaries of the NT.

Guidelines

The economic impact assessment was prepared with reference to the *Guidelines for the Preparation of an Economic and Social Impact Assessment* (NT EPA 2013d).

Economic modelling

Computable general equilibrium modelling was used to estimate the economic impact from the construction and operation of the Proposal. The model used was 'Tasman Global' developed by ACIL Allen.

In this model, a reference case simulation forms a 'business-as-usual' basis with which to compare the results of various simulations. The reference case provides projections of growth in the absence of a proposed project in terms of gross product, population, labour supply, industry output and so on and provides projections of endogenous variables such as productivity changes and consumer tastes. The policy case assumes all productivity improvements, tax rates and consumer preferences change as per the reference case projections but also includes the impacts of a proposed project. The two scenarios give two projections of the economy and the net impact of a proposed project is then calculated as deviations from the reference case (refer to Figure 12-1).

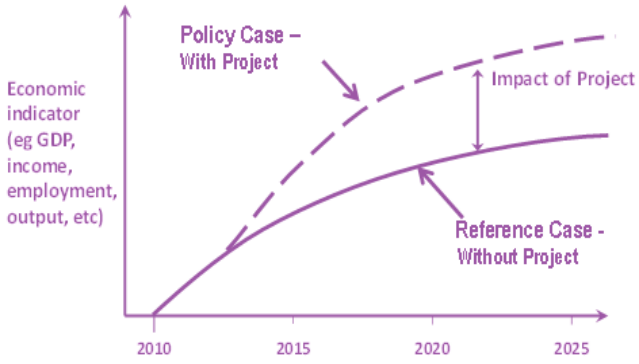


Figure 12-1 Illustrative scenario using Tasman Global

Economic modelling was undertaken concurrently for the construction and operational phases of the Proposal. In total, 25 years of data was modelled including four years of construction (the operational phase is able to start immediately and so the construction and operational phases run concurrently for the first four years). Three regions were modelled – the local region, the NT and Australia.

12.2.2 Social impact assessment

The methodology for the social impact assessment involved scoping key areas for study based on a risk and opportunity matrix that informed an initial grouping of social impacts. A baseline of the existing social environment was then developed based on qualitative and quantitative research, stakeholder consultation, and a literature review. The baseline was used to analyse the significance of potential positive and negative impacts of the Proposal.

Data sources

Data regarding the description of the existing social environment was obtained from publicly available sources. As with the economic impact assessment, the primary source of data was from the ABS including the 2011 Census. Workforce size and unemployment data was sourced from the NT

Department of Employment, Education and Training. Data was collected for the local region and for the NT.

Guidelines

The social impact assessment was prepared with reference to the following guidelines:

- *Guidelines for the Preparation of an Economic and Social Impact Assessment* (NT EPA 2013d)
- *International Principles for Social Impact Assessment* (IAIA 2003).
- *Social Impact Assessment: Guidance for Assessing and Managing the Social Impacts of Projects* (IAIA 2015).
- *IAP2's Public Participation Spectrum* and *IAP2 Core Values* (IAP2 2014 and IAP2 2016).

Consultation

The social impact assessment draws on consultation with key stakeholders. The key stakeholders interviewed during the preparation of the social impact assessment are listed in Chapter 5 and in Appendix U.

12.2.3 Notes on the data

The following should be noted when reading and interpreting this chapter:

- All data is presented in calendar years.
- All data is presented in Australian dollars.
- All data is presented in real dollars (this means that its value has been adjusted for inflation).
- All operations employment figures exclude temporary employees associated with activities such as planned shutdown maintenance and ad hoc scopes of work.
- The four years of construction from 2017 to 2021 inclusive plus 25 years of operations from 2017 to 2041 is referred to as the 'life of the Proposal'.

12.3 Existing environment

This section provides an overview of the existing economic and social environment of the NT. An overview of the economic and social environment of the local region is also provided.

12.3.1 Population

The following sections describe the population of the NT and the local region as well as highlighting the contribution that the Sandover Plenty SA2 and the Alice Springs Local Government Area make to the local region.

Population density and distribution

The estimated resident population of the NT is currently just over 245,000 people with the majority of the population concentrated around the capital city of Darwin, and the central Australian town of

Alice Springs. The current population of the local region is 33,164 which is around 14% of the population of the NT (refer to Table 12-1).

The local region comprises the Sandover Plenty SA2 area and the Alice Springs Local Government Area. The Sandover Plenty SA2 area is sparsely populated and has a current population of 4,497. The Alice Springs Local Government Area has a current population of 28,667 people of whom most live in the town of Alice Springs. This is equivalent to just under 12% of the population of the NT and 86% of the population of the local region (refer to Table 12-1).

There are a number of small population centres located in the areas surrounding the proposed Chandler Facility. These include the Aboriginal communities of Santa Teresa and Titjikala which are located in the Sandover Plenty SA2 area and Finke which is located to the south of Sandover Plenty SA2. Together, these towns have a population of just over 900 people of which 555 live in Santa Teresa (refer to Table 12-1).

In terms of population density, the NT is home to around 0.2 persons per square kilometre and the local region is home to 0.3 persons per square kilometre. However, in the areas outside of the Alice Springs Local Government Area, the population density is far less at 0.03 persons per square kilometre.

Table 12-1 Population estimates

Location	Population
Northern Territory (2014)	245,000
Local region (2014)	33,164
Local region (Sandover Plenty SA2) (2014)	4,497
Local region (Alice Springs Local Government Area) (2014)	28,667
Finke (2011)	162
Santa Teresa (2011)	555
Titjikala (2011)	201

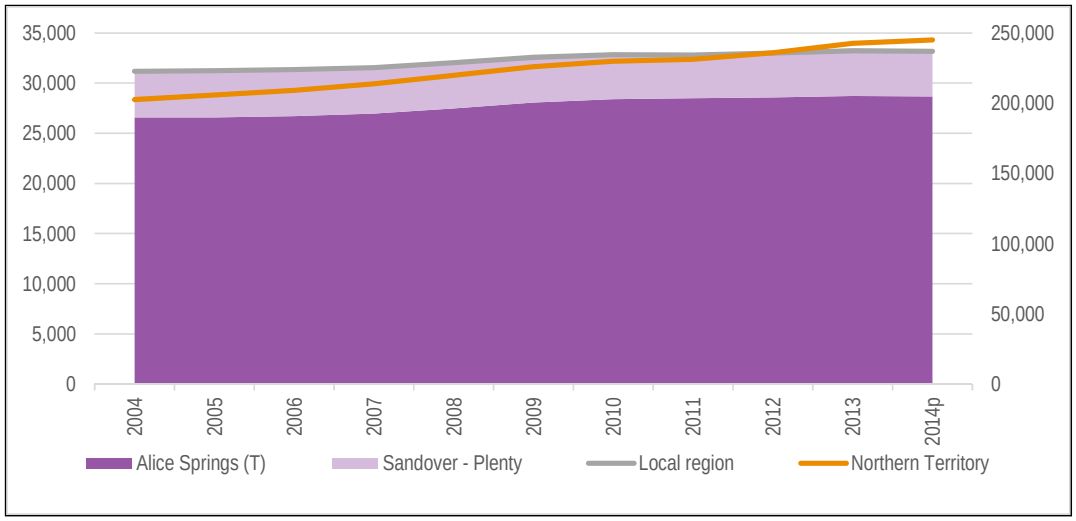
Source: Australian Bureau of Statistics

Historical population growth

The estimated resident population of the NT and the local region over the decade from 2004 to 2014 is shown in Figure 12-2. The population of the local region has experienced slight growth of around 0.6% per annum since 2004 which is equivalent to around 200 people per year. Nearly all of this growth has come from population increases in the Alice Springs Local Government Area which has recorded population growth of 0.7% per annum equivalent or just over 200 people per year.

In the areas outside of the town, there has been negative population growth of around 0.2 % or a loss in population of just under ten people each year. Population in the local region has plateaued since 2010 and has experienced a slight decline from 2013 to 2014 of 0.2 % as a result of population decline in the Alice Springs Local Government Area and in the Sandover Plenty SA2 area.

In comparison, the population of the NT has risen by an average of 1.7 % per annum over the decade to 2014 as a result of large increases in Darwin of around 1.6 %. However, NT population growth has also slowed in the year to 2014 to around 1.0 % per annum.



Source: Australian Bureau of Statistics

Figure 12-2 Estimated Resident Population: Northern Territory and local region (2004 – 2014)

Population forecasts

The population of the NT and the local region, along with their recent population growth and estimates of their expected growth is provided in Table 12-2. The population of the local region is expected to grow at around 1.3 % while the population of the NT is expected to continue to increase at around 1.7 %. The lower growth in the local region is a result of little to no growth expected in the Sandover Plenty SA2 area in line with 10-year historic growth rates.

Table 12-2 Population and population growth estimates

Location	Population	Population growth 2013-2014	Population growth forecast (2013-14 to 2018-19)	Population forecast (2018-19)
Northern Territory	245,000	1.0%	1.7% per annum	261,966
Local region*	33,164	-0.2%	1.3% per annum	35,775
Local region (Sandover Plenty SA2)*	4,497	-0.5%	0.0% per annum	5,000
Local region (Alice Springs Local Government Area)*	28,667	-0.2%	1.6 % per annum	31,280

Source: Australian Bureau of Statistics.

** Estimated by Acil Allen based on regional population projections published by the Northern Territory Government (NT Government 2015).*

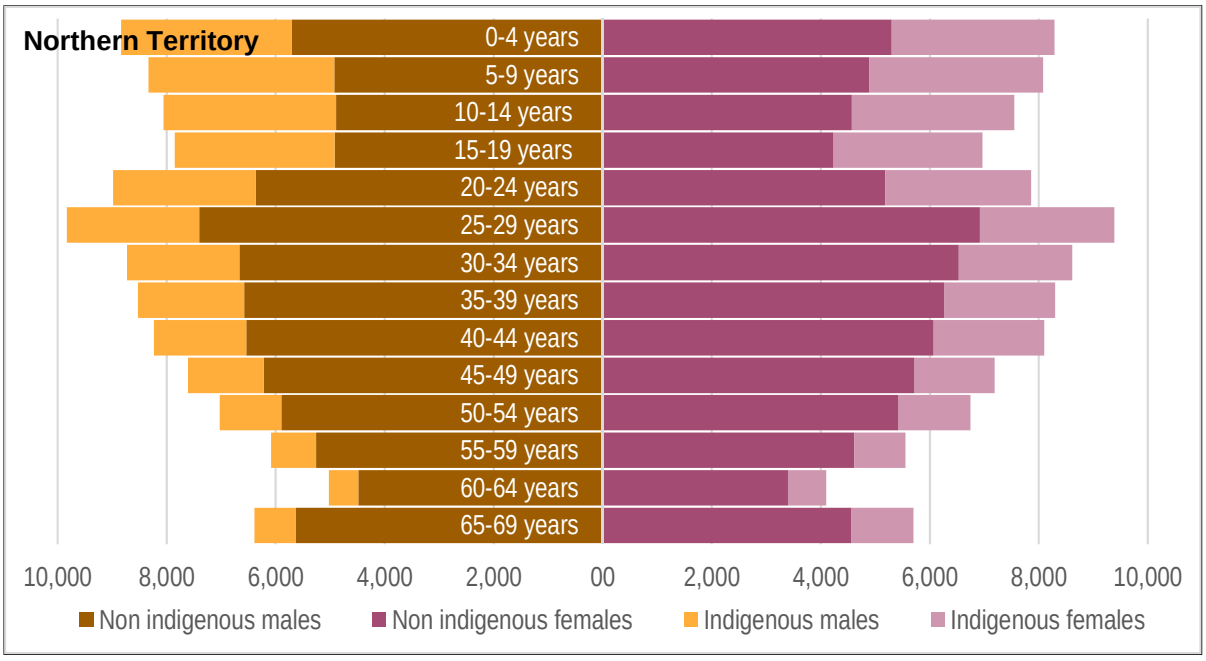
12.3.2 Demography

The age and gender profile of people living in the NT and the local region is presented in Figure 12-3 and Figure 12-4. The NT and the local region both have fairly standard population profiles which are characterised by a higher number of people of working age and are typical of larger populations.

However, the demographic profile of the local region shows a comparative lack of population in the 20 to 29 age groups suggesting that people from this demographic leave the region to find employment and life experience elsewhere.

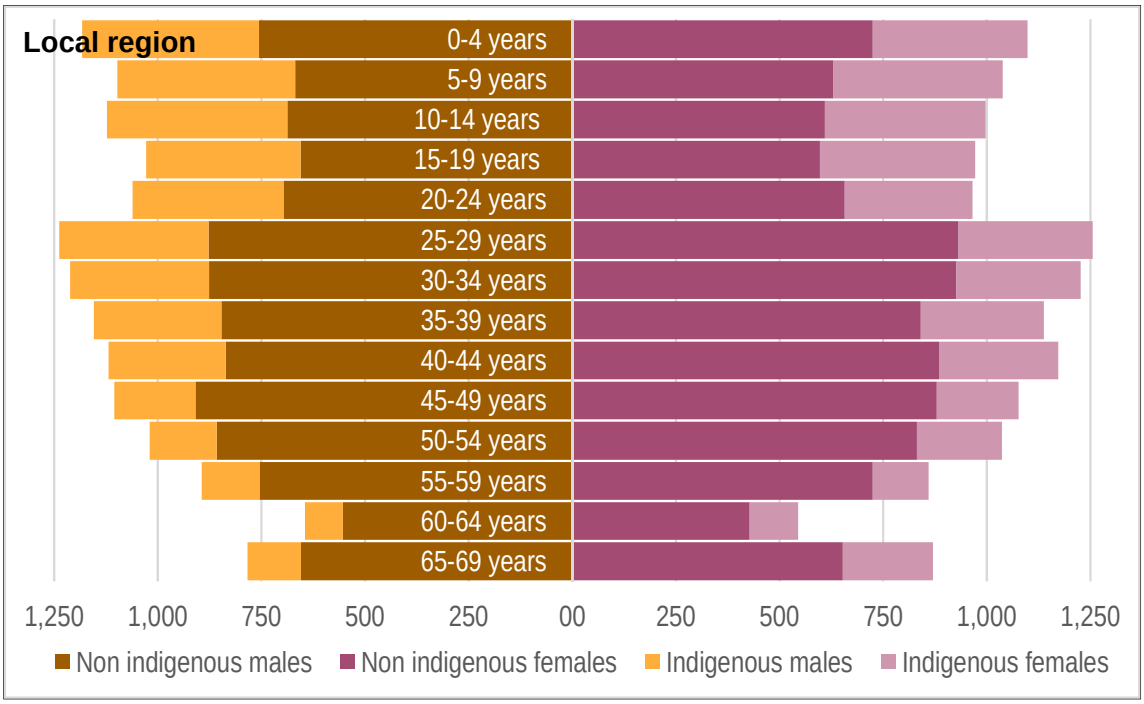
The profiles also show the large number of indigenous people that live in the NT, particularly in the local region. Around 27 % of the population of the NT is indigenous, while 28 % of the local region is indigenous.

The demographic profiles of the Alice Springs Local Government Area and the Sandover Plenty SA2 area are shown in Figure 12-5 and Figure 12-6 (respectively) to illustrate the differences in the two areas that make up the local region. The local region is dominated by the demographic profile of Alice Springs as this is where most of the population from the region lives. In contrast, the Sandover Plenty SA2 area has a very large Aboriginal population comprising 89% of the population. There is very large male population in the area and a higher number of people in the 20 to 29 age groups.



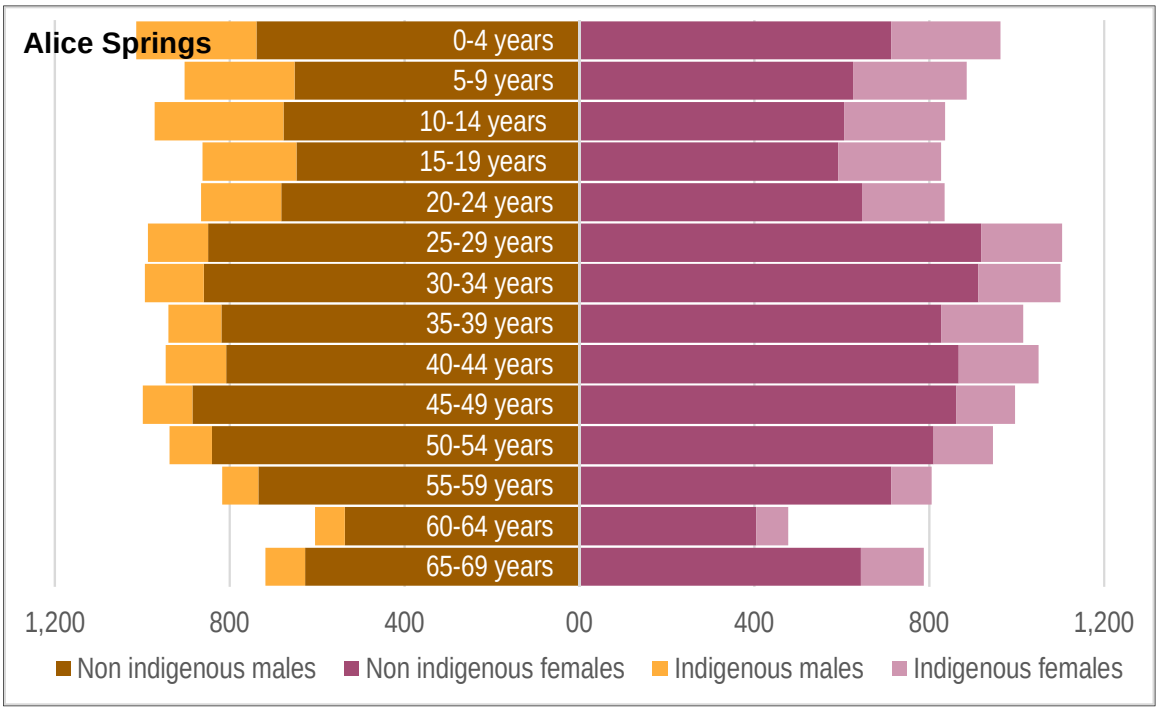
Source: Australian Bureau of Statistics

Figure 12-3 Age and gender profile: indigenous and non-indigenous people in the Northern Territory

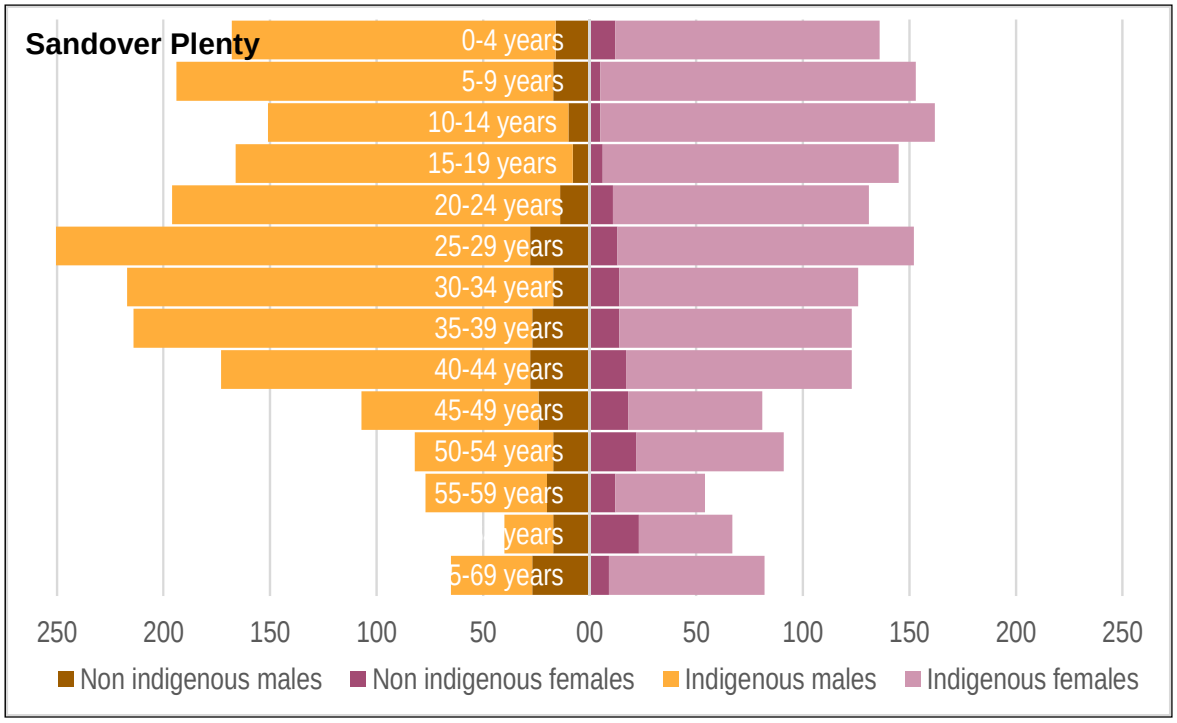


Source: Australian Bureau of Statistics

Figure 12-4 Age and gender profile: indigenous and non-indigenous people for the local region



Source: Australian Bureau of Statistics



Source: Australian Bureau of Statistics

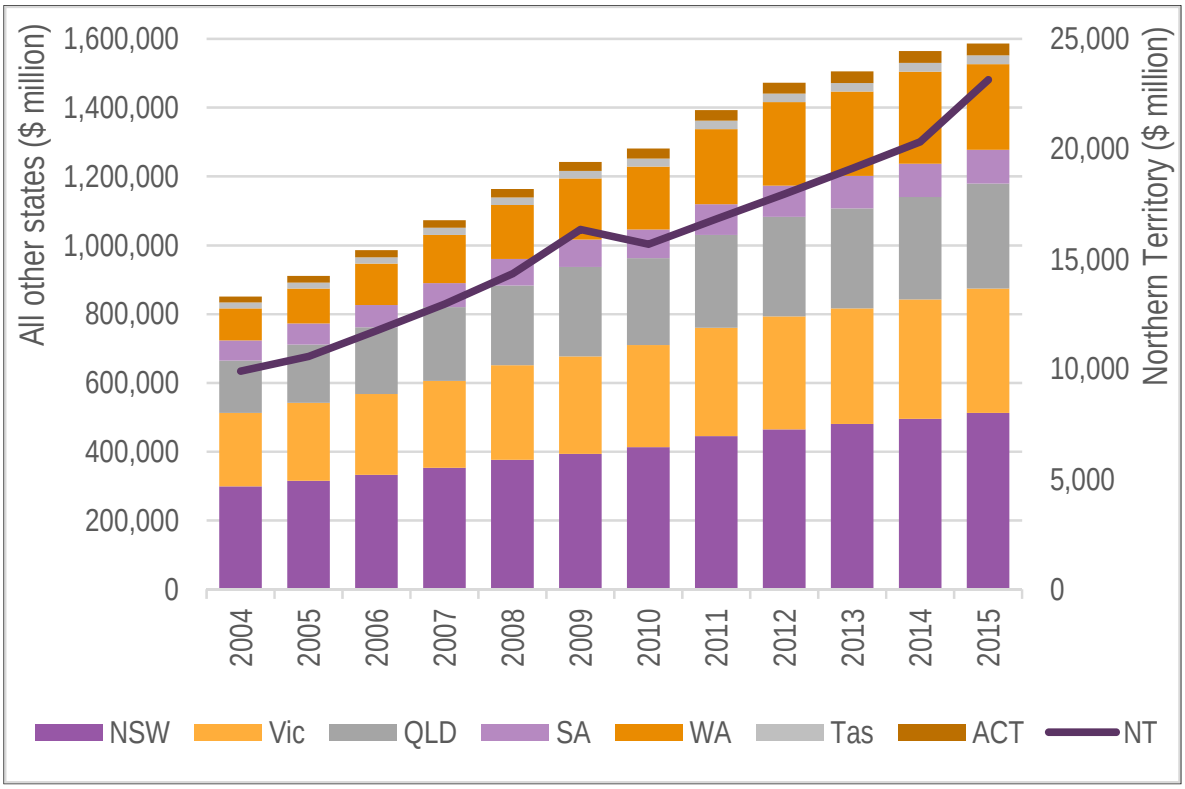
Figure 12-6 Age and gender profile: indigenous and non-indigenous people in Sandover Plenty SA2

12.3.3 Overview of the economy (NT)

This section provides information regarding the gross state product of the NT. Historic and forecast economic growth is also outlined.

Gross state product

The value of the gross state product of the NT was worth $23.1 billion in 2014-15. This is equivalent to 1.4 % of Australia's gross domestic product which was worth $1.6 trillion in 2014-15 and is the smallest share of Australia's total gross domestic product as shown in Figure 12-7.



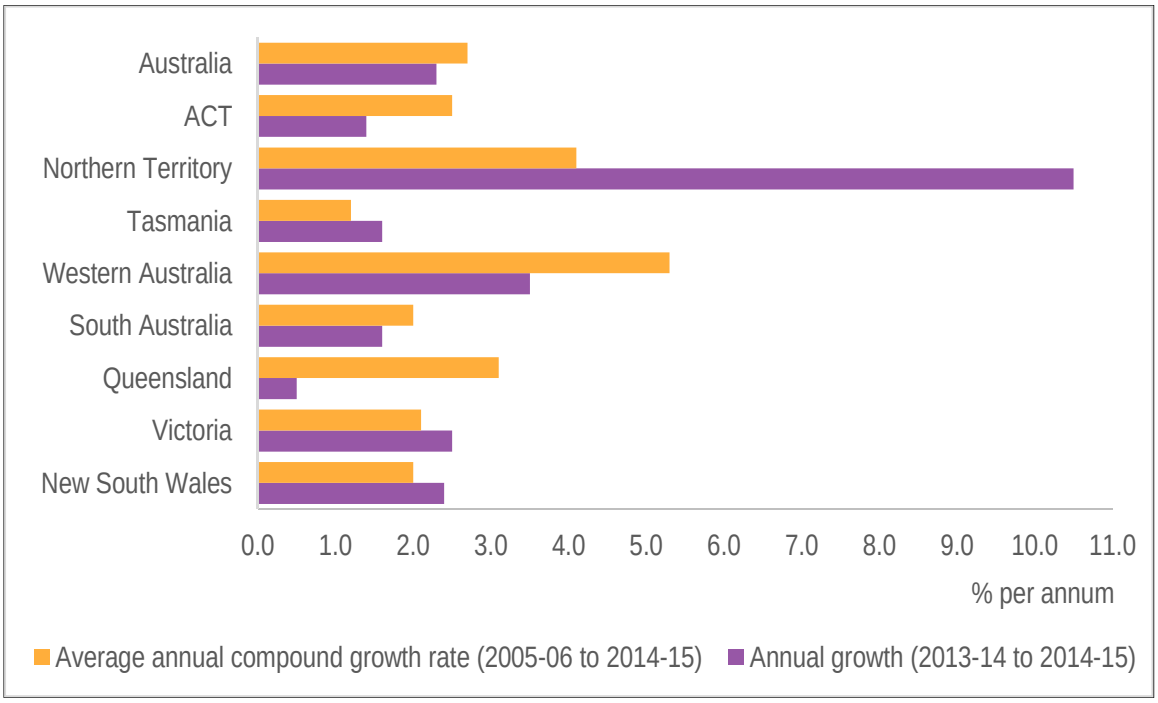
Source: Australian Bureau of Statistics

Figure 12-7 Value of gross state product by state (2004-2015)

Historic economic growth

Whilst the NT contributes only a small share of Australia's gross domestic product, it is currently experiencing very high rates of growth, as shown in Figure 12-8. In the period from 2013-14 to 2014-15, the gross state product of the NT grew in real terms by 10.5% which was the highest growth rate of any state or territory in Australia and the highest rate of growth experienced by the NT over the past decade. The reason for this growth was the large investments associated with the construction of major projects such as the Ichthys Project Onshore LNG Facilities. In contrast, the gross domestic product of Australia grew by 2.3% over the same time period.

Growth in the NT gross state product is fairly volatile due to the small size of the economy and the comparatively large impact of major projects and global market conditions. Over the decade to 2014-15, the gross state product of the NT grew by an average annual compound growth rate of 4.1% per annum which is the second highest of any jurisdiction behind Western Australia whose economy grew by 5.3% per annum and far less than the 10.5% growth experienced by the NT over the last year. In comparison, the gross domestic product of Australia grew by an average of 2.7% per annum over period 2005-06 to 2014-15.



Source: Australian Bureau of Statistics

Figure 12-8 Gross state product average annual growth

Forecast economic growth

The NT Government forecasts economic growth in the NT to moderate from current levels to reach 4.5 % in 2014-15, where it will remain until 2016-17. This rate is above historical trend levels and reflects the ongoing effects of business investment in the NT. After 2015-16, the economy of the NT is expected to transition from one of high growth led by the construction of major developments including the Ichthys Project Onshore LNG Facilities, the Darwin Marine Supply Base and the Defence Support Hub to one of above trend growth of around 3 % per annum led by the production phases of these major investments (NT Treasury 2015).

In comparison, the Federal Government forecasts that gross domestic product growth in Australia will remain well below forecasts for the NT. Real gross domestic product growth is expected to remain constant in 2014-15 at 2.5 % before gradually increasing to reach 3.25 % in 2016-17 (The Treasury 2014).

12.3.4 Overview of the economy (local region)

The economy of the local region is driven by the town of Alice Springs as the major service and supply base for the population of Central Australia and particularly for the surrounding Aboriginal population. It also supports the mining and agricultural industries, the tourism sector, and the Joint Defence Facility at Pine Gap.

There are a range of industries including the government sector, the construction industry, the retail trade industry and the tourism sector in Alice Springs. Despite this, the town has a fairly limited

economic base that is heavily skewed towards the government sector and the provision of government services in the areas of public administration (e.g. police and welfare), education and training, health and the local government sector.

In the Sandover Plenty SA2 area, the economy is reasonably diverse, however, there are relatively few job opportunities for local people. As of the 2011 Census there were 1,260 people counted as working in the area. This number provides an indication of jobs because it includes people from outside of the area who work in Sandover Plenty SA2. However, the Census only records 655 people who live in the area as in employment. This would indicate that many of these jobs are staffed by people from outside of Sandover Plenty SA2.

A large number of jobs in Sandover Plenty SA2 are located at the Joint Defence Facility at Pine Gap with the other major employers being the government sector including the local government sector, and those that supply goods and services to the local population such as the retail trade and utility provision industries. Agriculture and mining are also relatively large employers in the area providing just over 8 % of jobs in the Sandover Plenty SA2 area.

12.3.5 Major industries (NT)

Mining, government, agriculture and tourism are the major industries in the NT. Together, these industries account for almost 40 % of the gross domestic product of the NT.

- **Mining**. The mining sector is the most significant industry in the economy of the NT. In 2014-15, the mining sector accounted for around 12.3 % of the gross state product of the NT. The major commodities are manganese, gas and liquids, and liquefied natural gas production. There are four major producing mines in the NT. These are the Alcan Gove Mine, Gemco Mine, McArthur River Mine and the Tanami Gold Mine. In 2014-15, the value of mining production in the NT was estimated to be $3.2 billion.
- **Government**. The government sector provides a significant contribution to the economy through the provision of services such as government administration, defence, education and health. Together they account for around 18.3 %t of the gross state product of the NT. The defence sector is a major contributor to the economy of the NT. It generates around 6.9% of the gross state product of the NT. Defence spending increased by 10.6 % or $144 million to $1.5 billion in the NT in 2013-14.
- **Tourism**. In 2013-14, the tourism sector accounted for around 4% of the gross state product of the NT. It is also one the largest employers in the Northern Territory providing around 8,000 jobs or 5.7% of employment (NT Treasury 2015).
- **Agriculture, forestry and fishing**. The agriculture sector comprises cattle and other livestock (including buffalo, crocodiles, poultry, pigs and camels), horticulture (fruit, vegetables, nursery and cut flowers) and mixed farming (field crops, hay and seeds, and forestry). In 2014-15, the agriculture, forestry and fishing industry accounted for 1.8 % of the gross state product of the NT.

12.3.6 Businesses

Darwin is the main service centre for the NT supporting a wide range of industries including the government sector, the oil and gas industry, mining and the defence sector. It continues to position itself as a strategic position for shipping, regional freight and as a distribution gateway. There are around 14,500 businesses in the NT as of June 2014 with the greater Darwin area home to around 71 % of businesses while nearly 16 % of businesses are located in Alice Springs (NT Department of Business 2015). A number of large projects have been constructed in the NT in recent years. These include the INPEX Ichthys LNG Project, the Darwin Marine Supply Base, the Defence Support Hub, and Darwin Waterfront Precinct which are all either in, or close to completion. The construction and operation of all of these projects have required businesses located in Darwin for the supply of goods and services. There are therefore a number of businesses located in Darwin with recent experience in supporting the construction and subsequent operation of a developments that are comparable to the Proposal.

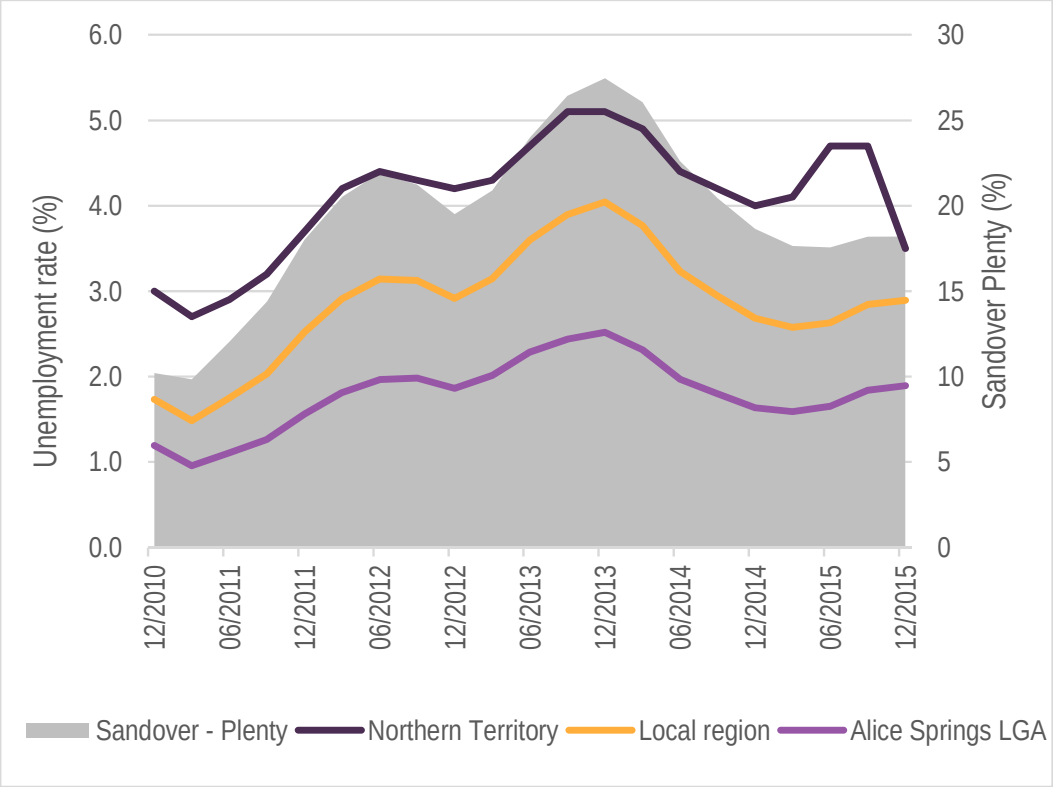
The business sector in the local region is dominated by the town of Alice Springs. Alice Springs supports nearly 2,300 businesses including those in the construction, food and accommodation, transport and logistics, financial services and so on. As the business hub for the surrounding region including the mining sector, there are businesses located in the town that can support the construction effort and the operations phase of the Proposal. There are very few businesses located in the local region that are located outside of Alice Springs. Most businesses are involved in the pastoral industry or in the provision of goods and services to local communities.

12.3.7 Workforce

There is a large workforce in the NT of nearly 122,000 people of which around 6,000 are currently seeking work. This equates to an unemployment rate in the NT of around 4.2% (2015).

The unemployment rate in the NT and in the local region for the period from December 2010 through to December 2015 is shown in Figure 12-9. The workforce in the local region comprises of around 20,500 people of which nearly 19,300 are located in the Alice Springs Local Government Area and the remaining 225 in the Sandover Plenty SA2 area.

The unemployment rate in the local region is currently 2.7 %which is well below the rate for the NT and indicates only 560 job seekers in the region. While around two thirds of these job seekers are located in Alice Springs, there is a comparatively higher number of job seekers in the Sandover Plenty SA2 area. This is represented by a much lower unemployment rate in Alice Springs of 1.7 % compared to an unemployment rate in Sandover Plenty of 17.9 %. This higher unemployment rate is reflective of the limited job opportunities in these areas and the difficulties that job seekers face in securing employment. Furthermore, it is likely that there are other people from the area that are not currently seeking work due to the low expectation of gaining employment resulting in an unemployment rate that is not reflective of the actual number of job seekers in the area.



Source: Department of Employment - Note: People aged 15 to 65

Figure 12-9 Unemployment rate: NT and local region

Industry of employment

The industry of employment for residents of the NT and the local region is shown in Figure 12-10. About 40% of the employees in the NT are employed in the industries of public administration and safety, education and training and health care and social assistance which largely reflect the industries that comprise the government sector including services provided by local, NT and federal governments. In comparison, 43% of the local region are employed in this sector.

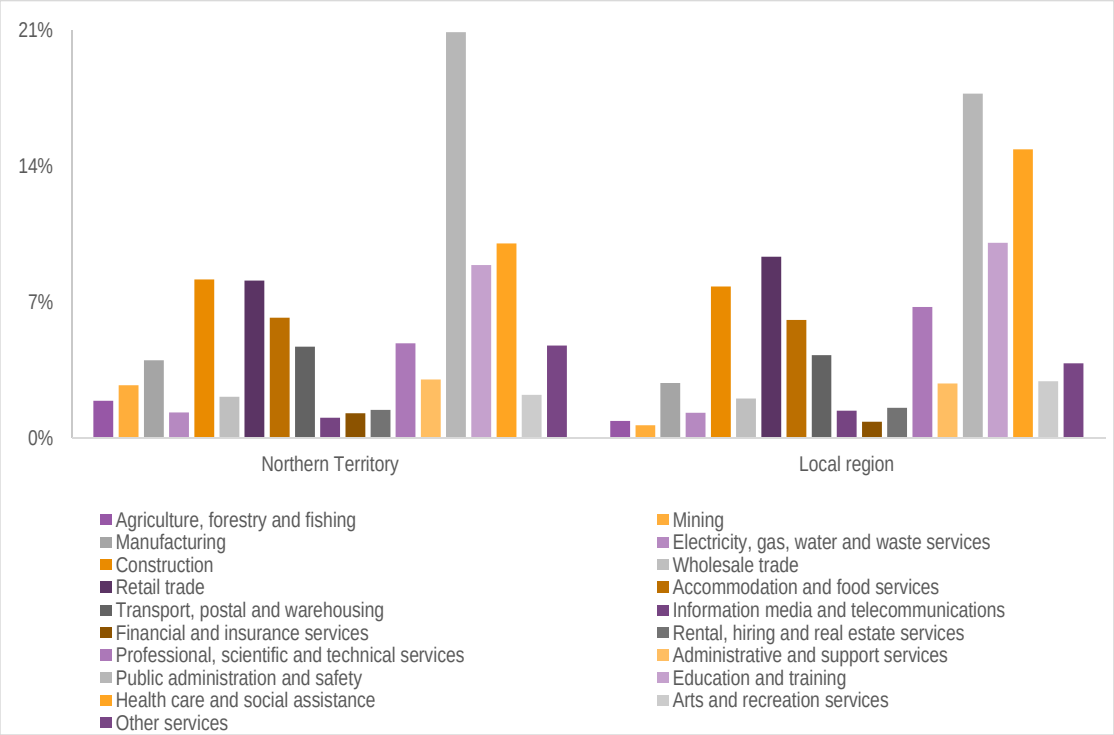
The employment profile of the local region is dominated by the workforce of Alice Springs where 95% of the employed workforce was located in 2011. In the Sandover Plenty SA2 area, the reliance on the government sector as the major employer is even more pronounced with 51% (335 of the 655 people employed) of the working population employed in this sector.

The three main industries of employment in the NT are the public administration and safety industry with 21% of total employment, the health care and social assistance industry (10%) and the construction industry with 8.2% of total employment. The three main industries of employment in the local region are the government related industries of public administration and safety (18%), health care and social assistance (15%) and education and training (10%). Retail trade is also an important employer in the local region employing just over 9% of employed persons that live in the region. These industries reflect the role of the town of Alice Springs as a regional service centre and population base.

The employment profile of the local region largely reflects the profile of the Alice Springs Local Government Area. In the Sandover Plenty SA2 area, the employment profile is quite different with the main industries of employment being public administration and safety (28 %), education and training (13 %), and agriculture, forestry and fishing (11 %). The other services (8 %) and retail trade (6 %) industries are also important employers where other services includes industries such as repairs and maintenance to vehicles and machinery, hairdressers, religious providers and household services. These key employers reflect the basic nature of the economy in the Sandover Plenty SA2 area that focusses on the provision of goods and services to the local community and the role of the pastoral industry in the economy.

As of the 2011 Census, the mining industry was a relatively small employer in the NT accounting for just under 3% of jobs compared to less than 1% of employment in the local region. Nevertheless, the industry provides good opportunities for local people employing 93 residents of the Local region in 2011 including 73 in the Sandover Plenty SA2 area.

In 2013−14 the mining industry directly accounted for 4.3% of total resident employment in the NT (NT Treasury 2015). Given the closure of several mines in the NT in recent years, including all of the NT's iron ore mines, it is likely that this share has fallen.



Source: Australian Bureau of Statistics 2011. Employed Persons aged 15 and over

Figure 12-10 Industry of employment: NT and local region (percentage of total employed persons aged 15+)

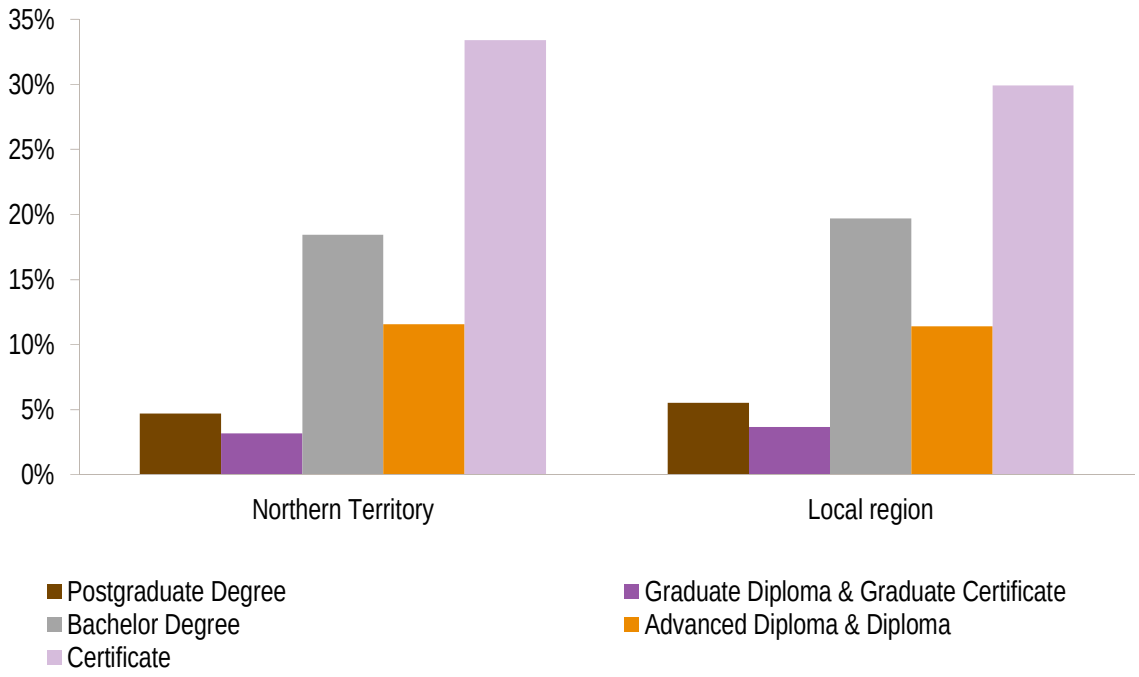
Skills level

About 57% of people aged 15 and over in the NT hold a non-school qualification compared to 60% in the local region.

Figure 12-11 shows the non-school qualifications of people aged 15 and over who hold a qualification and who live in the NT, compared to those that live in the local region as of the 2011 Census. In both regions, the most commonly held qualification is a Certificate.

In the local region, 29% of qualified people hold a bachelor degree or higher (postgraduate degree, graduate diploma and graduate certificate, and bachelor degree) while the equivalent for the NT is 26%. The higher qualifications in the local region are a result of the occupation profile in the Alice Springs Local Government Area which supports a large number of government workers and other tertiary qualified people. In the areas outside of Alice Springs, only 7% of the population with a qualification hold the same level of qualifications compared to 31% in Alice Springs.

In terms of absolute numbers, the number of qualified people in the local region with a bachelor or higher degree is 3,860 people which is 16% of all the people in the NT with these qualifications. The Alice Springs Local Government Area accounts for 3,761 of these people. In contrast, the Sandover Plenty SA2 area has 99 similarly qualified people accounting for just 0.4%of the NT total.



Source: Australian Bureau of Statistics 2011

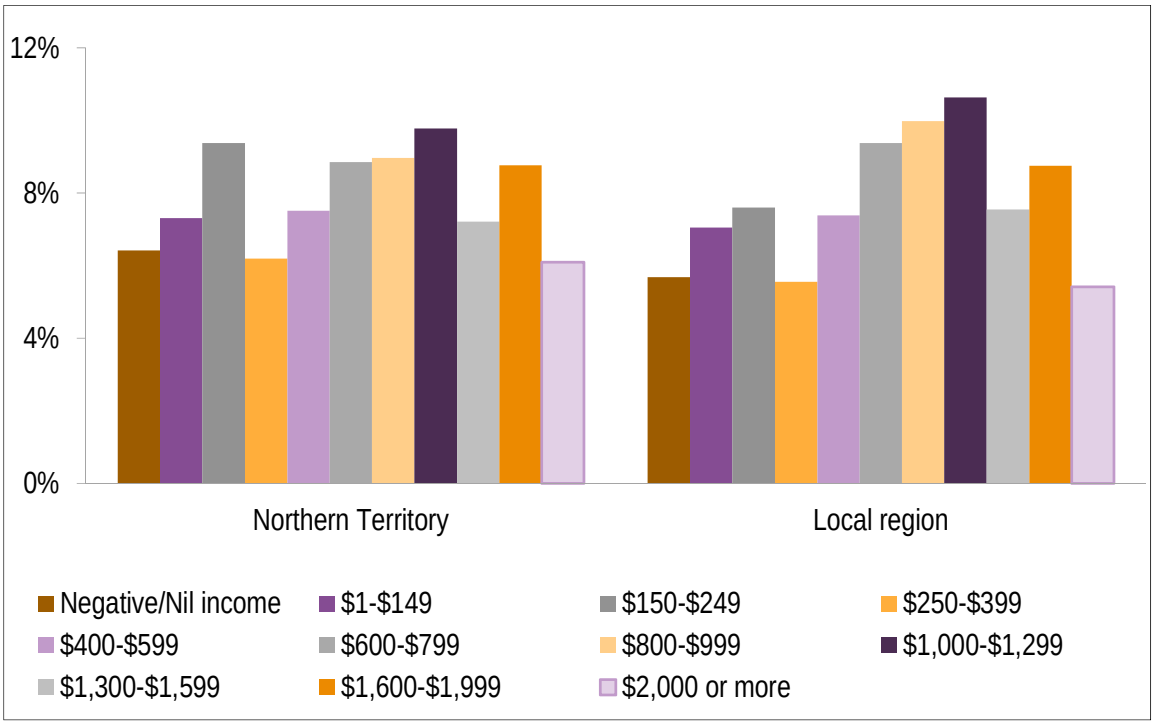
Figure 12-11 Non-school qualification NT and local region (percentage of total persons with a qualification aged 15+)

Income

The 2011 Census recorded 32% of the population in the NT earning in excess of $1,000 per week and 6% of the population earn in excess of $2,000 per week. The local region also recorded 32% of the population in the NT earning in excess of $1,000 per week, however, 12% of the population earned in excess of $2,000 per week (refer to Figure 12-12).

Incomes in the Alice Springs Local Government area are comparatively high with 36% of the population earning in excess of $1,000 per week and 6% earning in excess of $2,000 per week. This is equivalent to 14% of all of the people in the NT in this wage bracket. These higher earnings are because there are a high number of tertiary qualified people and people working in professional occupations who tend to earn higher incomes living in the town.

Just 5% of the population of the Sandover Plenty SA2 area earn in excess of $1,000 per week and 1% earn in excess of $2,000 per week.



Source: Australian Bureau of Statistics 2011

Figure 12-12 Personal weekly income: NT and local region (percentage of total persons aged 15 and over)

12.3.8 Infrastructure

The following sections provide a brief overview of the key economic and social infrastructure in Darwin and Alice Springs being the centres that are most likely to support the Chandler Facility through the provision of the majority of goods, services and labour.

Darwin

Darwin is the main population centre in the NT and is the key government and services sector for the NT. It offers a modern standard of living and a high standard of social infrastructure expected of a city.

The city is a significant part of the AustralAsia Trade Route, which includes: the AustralAsia Railway that links Darwin to the national rail network, an expanded East Arm Port, abundant industrial land at the adjoining Darwin Business Park and a growing number of shipping links with Asia.

Darwin is becoming an important supply, service and distribution base for major minerals and energy projects located in the north of Australia, the Timor Sea and South-East Asia. In the near term, significant investment from the INPEX Ichthys LNG Project which is nearing completion, the Darwin Marine Supply Base and the Defence Support Hub will continue to underpin the continued rapid growth in the Darwin economy. The operation of these developments will provide growing demand for employment and goods and services to support their production phases. At the same time, large lifestyle developments such as the Darwin Waterfront Precinct will enhance the social, cultural and general liveability aspects of the city for residents and tourists.

Alice Springs

Alice Springs is the largest population centre in central Australia and is the service centre for the surrounding region. It is well serviced by transport infrastructure due to its location on the Stuart Highway and the Adelaide to Darwin railway. The Alice Springs Airport is the major airport for the region providing air links to all of the mainland capital cities in Australia as well services to Cairns, Tennant Creek and Uluru.

Alice Springs is a modern and well catered for town with a good level of social infrastructure. Facilities include a teaching hospital, a university, childcare facilities, several high schools, numerous primary and preschools, a library and a variety of recreational facilities including two shopping malls and an aquatic centre. There are campuses of the Charles Darwin University and the Batchelor Institute located in town as well as a number of registered training providers. The town is the base of the Royal Flying Doctor service which provides 24-hour primary emergency retrievals and inter-hospital transfers. There is a public transport service that services areas within the town.

Finke, Santa Teresa and Titjikala

Finke, Santa Teresa and Titjikala are small Aboriginal communities that support a basic level of services and infrastructure. Finke is a very isolated community accessible by a 434-kilometre road that travels through Titjikala to Alice Springs. The community has a health care centre, school, church, community store, an airstrip and the NPY Women's Council Aboriginal Corporation that runs a number of services including a youth program and sport and recreation activities.

Santa Teresa which is the largest of the three communities is located approximately 85 kilometres south-east of Alice Springs. The town has several retail outlets including a general store, fuel supply, and art and craft centre. There is also a primary school, health clinic, police station a church and an airstrip.

Titjikala is located approximately 130 kilometres south of Alice Springs and supports an airstrip, a community store, primary school, art centre, health clinic and church.

12.3.9 Health services

Health care services located in the vicinity of the Proposal (Alice Springs, Titjikala, Finke and Santa Teresa) are listed in Table 12-3.

Table 12-3 Health care services in the vicinity of the Proposal

Health service	Description	Managing authority
Alice Springs Hospital	Services include general medicine, rehabilitation medicine, palliative care, nephrology, emergency medicine, anaesthesia, intensive care, surgery (including ophthalmology, orthopaedics and ear, nose and throat), psychiatry, paediatrics, obstetrics and gynaecology.	NT Government
Titjikala Health Clinic	Services include emergency care, medical evacuations (by road), preventable chronic disease, childhood and adult immunisations, men's and women's health checks, infectious and communicable disease prevention.	NT Government
Aputula Health Clinic (Finke)	Staffed by two registered nurses, two Aboriginal health workers and a visiting doctor. It has nine rooms with separate men's and women's waiting areas and consulting rooms. There is an emergency treatment room, pharmacy, office and laundry.	NT Government
Mpwelarre Health Aboriginal Corporation (Santa Teresa Health Centre)	Staffed by a community doctor who is non-resident but provides 24 hour telephone support to the clinic staff. The clinic is staffed by two remote area nurses and four Aboriginal health workers. There are also a range of health professionals in different fields that visit the community at varying intervals.	Private

12.3.10 Education services

Education services located in the vicinity of the Proposal (Alice Springs, Titjikala, Finke and Santa Teresa) are described below.

Alice Springs

Ten primary schools (seven government and three private) and five secondary schools (three government and two private) are located in Alice Springs. Tertiary education is provided by the Charles Darwin University, and the Batchelor Institute of Tertiary Education and the Centre for Appropriate Technology (brought together as the Desert Peoples' Centre). There is also a campus of the Flinders University for Remote Health in Alice Springs.

Finke, Santa Teresa and Titjikala

There are primary schools located in Finke, Santa Teresa and Titjikala and middle schools located in Finke and Santa Teresa:

- Finke – Finke (Aputula) School, current enrolment of 29 students.
- Santa Teresa – Ltyentye Apurte Catholic School, current enrolment of 140 students.
- Titjikala – Titjikala School, current enrolment of 25 students (including pre-primary students).

Once students from these communities reach senior years, they have the option of boarding in Alice Springs or going interstate to complete their education.

Vocational education training is provided in Santa Teresa and Titjikala by the Batchelor Institute of Tertiary Education.

12.3.11 Housing market

There is a high rental vacancy rate in privately owned accommodation and an easing in the private sales market in Alice Springs. However, there is a shortage of public housing availability with wait times for this type of housing more than doubling over the past decade in Alice Springs (NT Shelter 2016). There are no official statistics available regarding public housing in Santa Teresa, Finke or Titjikala. However, housing in remote areas is a key issue for people living in these communities because of critical shortages and overcrowding problems (Central Land Council 2016).

The median house price was $467,500 in Alice Springs in 2015. This compares to a median house price of $608,750 in Darwin in 2015 (Real Estate Institute of Northern Territory Inc 2016). The growth in median house prices is currently experiencing rates of around 1% per annum for houses and units in Alice Springs. There were no recorded house sales in the MacDonnell Regional Council area in 2015 (which includes Finke, Santa Teresa and Titjikala).

12.3.12 Social amenity

This section describes the social amenity of Alice Springs. There is very little publicly available information regarding the social amenity in the communities of Finke, Santa Teresa and Titjikala.

Alice Springs

Alice Springs supports a large population many of whom are Aboriginal. There is a growing middle-class of Aboriginal people in the town who are better educated and engaged in the workforce. At the same time, there is a large disadvantaged and more mobile population of Aboriginal people who tend to live in town camps, public housing and temporary accommodation. Many are transient and visit Alice Springs from remote communities to visit relatives, for recreation purposes such as to attend sporting events, or to access services.

There is a high crime rate in Alice Springs, as shown in Table 12-4. The rates of offending in Alice Springs are significantly higher than those experienced in Darwin (particularly those that relate to assault, domestic violence and alcohol related assault). Despite these very high levels, there has been a decline in offending rates for these crimes over the past year.

Table 12-4 Rates of offending per 100,000 population by crime (Darwin and Alice Springs)

Crime	Alice Springs			Darwin and Palmerston		
	Nov, 2014 - Oct, 2015	Nov, 2015 - Oct, 2016	% change	Nov 2014 - Oct 2015	Nov 2015 - Oct 2016	% change
Assault	5,915.9	5,522.4	-6.7	2,169.3	2,005.9	-7.5
Domestic violence related assault	3,461	3,246.1	-6.2	822.9	781.3	-5.1
Alcohol related assault	3,864.8	3,342.8	-13.5	1,268.9	1,115.6	-12.1
Sexual assault	251.5	286.3	13.8	157.4	145.8	-7.4
House break-ins	1,438.2	1,073.7	-25.3	766.8	787.2	2.7
Commercial break-ins	949.4	1,288.4	35.7	421	669.8	59.1
Motor vehicle theft	1,176.1	1,374.3	16.9	1,295.1	1,040.9	-19.6
Property damage	5,334.9	6,409.9	20.2	2,838.3	2,840.5	0.1

Source: Northern Territory Police

Titjikala

Titjikala comprises a number of family groups including Traditional Owners. Other Traditional Owners are dispersed between Alice Springs, Titjikala, Santa Teresa, Finke and other Arrernte communities such as Hermannsburg. Many Traditional Owners also live on traditional homelands at Walkabout Bore, Mt Peachy, John Holland Bore and Oak Valley.

In general, the community is well-functioning and proud with families mostly living in harmony. There is strong leadership in the town which has resulted in lease money being reinvested into community facilities.

There is no permanent police presence in Titjikala, although there is a strong night patrol that works from about 6 PM to midnight most days. Police patrols located at Finke and Santa Teresa currently service the community of Titjikala.

12.4 Assessment of impacts during construction and operation

This section summarises the financial and employment assumptions used in the economic and social impact assessment. Potential economic and social impacts that would arise during construction and operation are also presented. There would be significant economic and social benefits to the economy through direct spending associated with the construction and operation of the Proposal. There would also be indirect benefits which would result from the additional spending in the economy on goods, services and wages. Further detail is provided in Appendix U.

12.4.1 Key financial assumptions

The key financial assumptions for the Proposal are presented in Table 12-5. These assumptions are also discussed in further detail below.

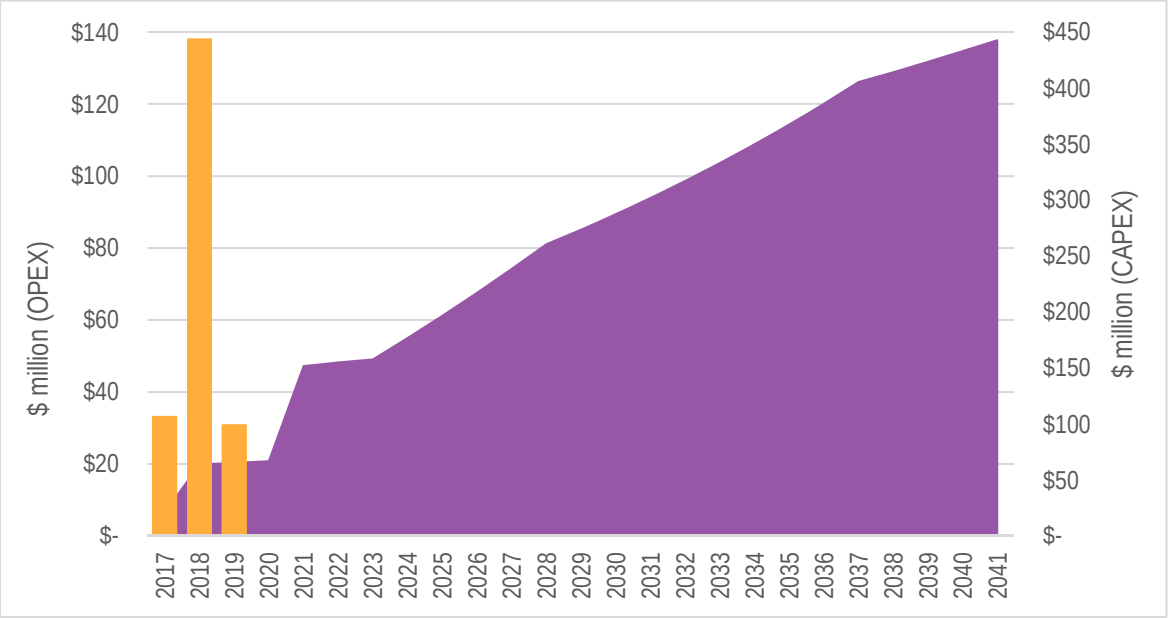
Table 12-5 Key financial assumptions for the Proposal

Item	Assumption	
Capital expenditure (2017-2020)	$676 million	
Operations expenditure (2017-2041)	$81 million per annum average	
Local content assumptions (construction expenditure)	Local	18%
	NT	36%
	Australia	67%
	Overseas	33%
Local content assumptions (operation expenditure)	Local	32%
	NT	52%
	Australia	64%
	Overseas	36%
Tax and royalty payments (directly paid by Chandler Facility)	$40 million per annum average	

Capital and operations expenditure

It is estimated that there would be a capital expenditure of around $676 million over a four year period from 2017 to 2020 on the Proposal. The majority of expenditure would occur in the first three years of construction, with peak construction expenditure occurring in the second year. On average, there would be a capital expenditure of $162 million in each of the four years of construction (refer to Figure 12-13).

Operations expenditure would start in the first year, which is also the first year of construction (2017). The amount of operations expenditure in the first few years would be small at around $20 million per annum but would continue to rise, reaching $137 million by 2041. On average, there would be spending of just under $81 million per annum to operate the Proposal (refer to Figure 12-13).



Note: Orange represents capital expenditure (CAPEX), purple represents operational expenditure (OPEX).

Figure 12-13 Capital and operational expenditure on the Proposal

Revenue

Revenue would be raised from salt sales, but the majority of revenue would be received from the storage of waste. Revenue would be realised from the first year of operation in the form of stored waste revenue and would continue to rise over time as the tonnage of stored waste increases.

Revenue estimates are considered commercial in confidence and have not been reported in the EIS. They have, however, been used to estimate the economic impact of the Proposal.

Local content assumptions

There would be high local content during both construction and operation of the Proposal. Around 67% of all construction costs would be spent in Australia. About 36 % of the total construction cost (just over $231 million) would be spent in the NT and 18 % of the total construction cost (just over $118 million) would be spent in the local region. Around 64 % of the total operation costs (including labour) would be spent in Australia. About 52 % of the total operational cost would be spent in the NT and 32 % would be spent in the local region. This is equivalent to spending in Australia of over $1.2 billion over the 25 modelled years of the life of the Proposal, including just over $1 billion in the NT. Of this, over $600 million would be spent in the local region with the majority of that expenditure expected to be spent in Alice Springs.

Tax and royalty payments

It is expected that $1 billion of direct taxation revenue would be paid to the NT and Federal Government over the life of the Proposal. This is equivalent to around $40 million per annum in direct taxation payments.

12.4.2 Key employment assumptions

The key employment assumptions for the Proposal are presented in Table 12-6 and in Figure 12-14. Over the construction period, it is expected that 1,299 full time equivalent workers would be employed. At peak construction there would be a full time equivalent workforce of around 720 workers. During steady state operations it is expected that 150 full time equivalent workers would be employed at the proposed Chandler Facility and Apirnta Facility (2021-2041).

Table 12-6 Key employment assumptions for the Proposal

Item	Assumption
Construction period	4 years or 48 months (2017-2020)
Peak construction	Year two (2018)
Construction workforce	1,299 full time equivalent jobs over four years
Peak construction workforce	720 full time equivalent jobs
Operational life	25 years (2017-2041)
Steady state production workforce	150 full time equivalent jobs

Note: FTE = Full time equivalent jobs per year

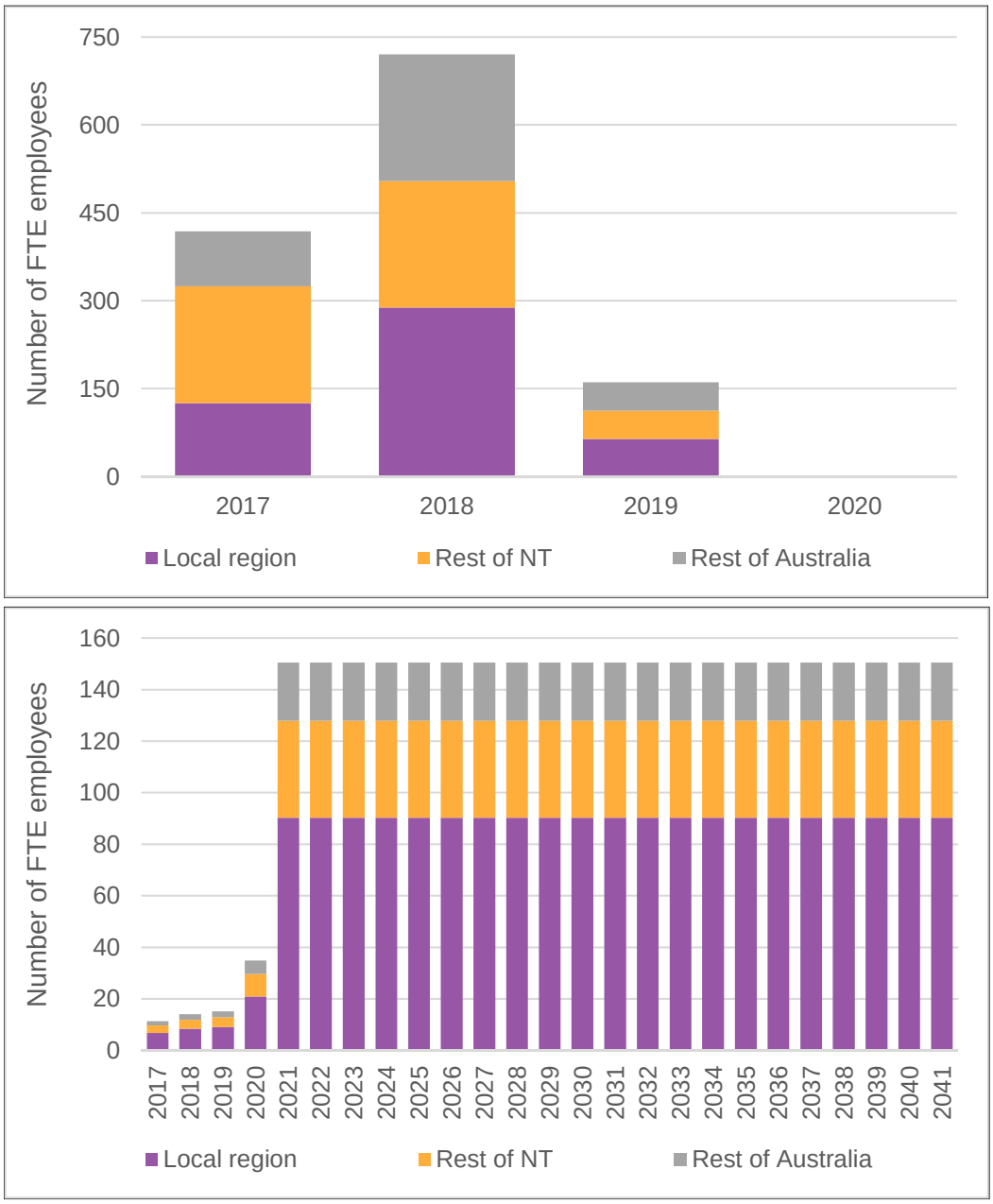


Figure 12-14 Direct employment during construction and operation of the Proposal

12.4.3 Contribution to gross product

Gross product or real economic output is a measure of the increase in the size of an economy. Real economic output is a measure of the output generated by an economy over a period of time (typically a year). It represents the total dollar value of all goods and services produced over a specific time period and is considered as a measure of the size of the economy.

About $3.6 billion or an average of $144 million per year would be generated over the life of the Proposal to the gross state product of the NT. This would result in a significant annual contribution to the gross state product of the NT and is equivalent to around 0.6% of the current gross state product of $23.1 billion (refer to Table 12-7).

Nearly all of the economic benefits would be realised in the local region, as shown in Figure 12-15. This is because production would occur in the local region and because it is where a large share of the labour is located.

The gross domestic product of Australia would rise by about $4.1 billion or an average of $166 million each year over the life of the Proposal (refer to Table 12-7).

Table 12-7 Projected cumulative change in gross product or real economic output

Location	Real economic output		
	Total (2017 to 2041)	Net present value	
		4%	7%
	2016 A$m	2016 A$m	2016 A$m
Local region	3,600	1,990	1,350
Rest of NT	-17	1	8
Rest of Australia	560	310	210
Total NT	**3,590**	**1,995**	**1,360**
Australia	**4,150**	**2,300**	**1,570**

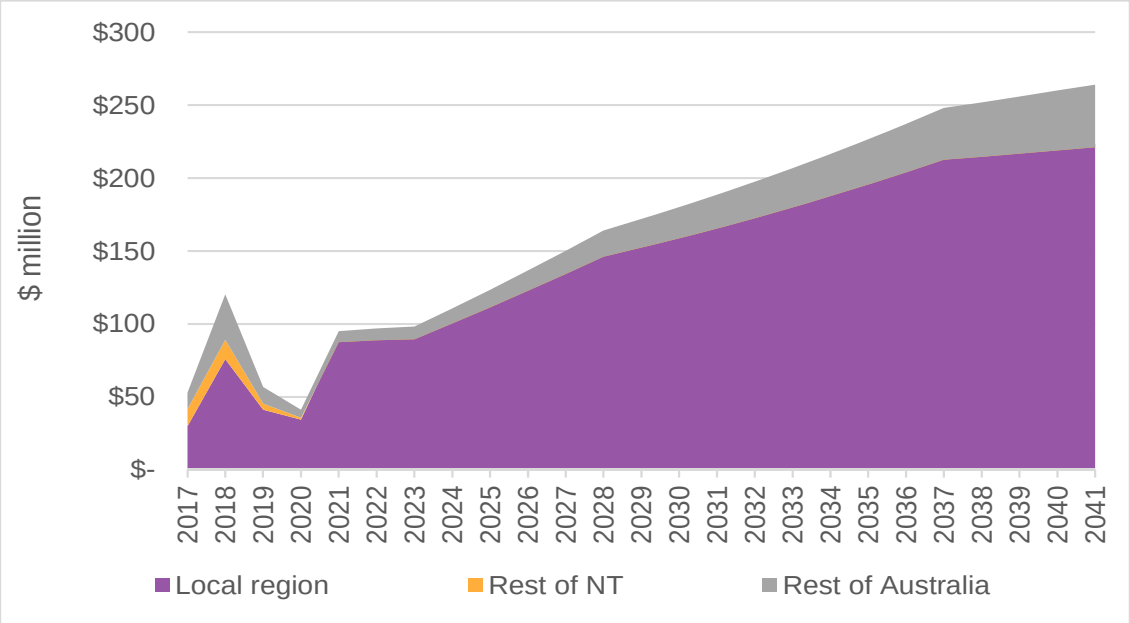


Figure 12-15 Contribution to gross product or real economic output

12.4.4 Contribution to real incomes

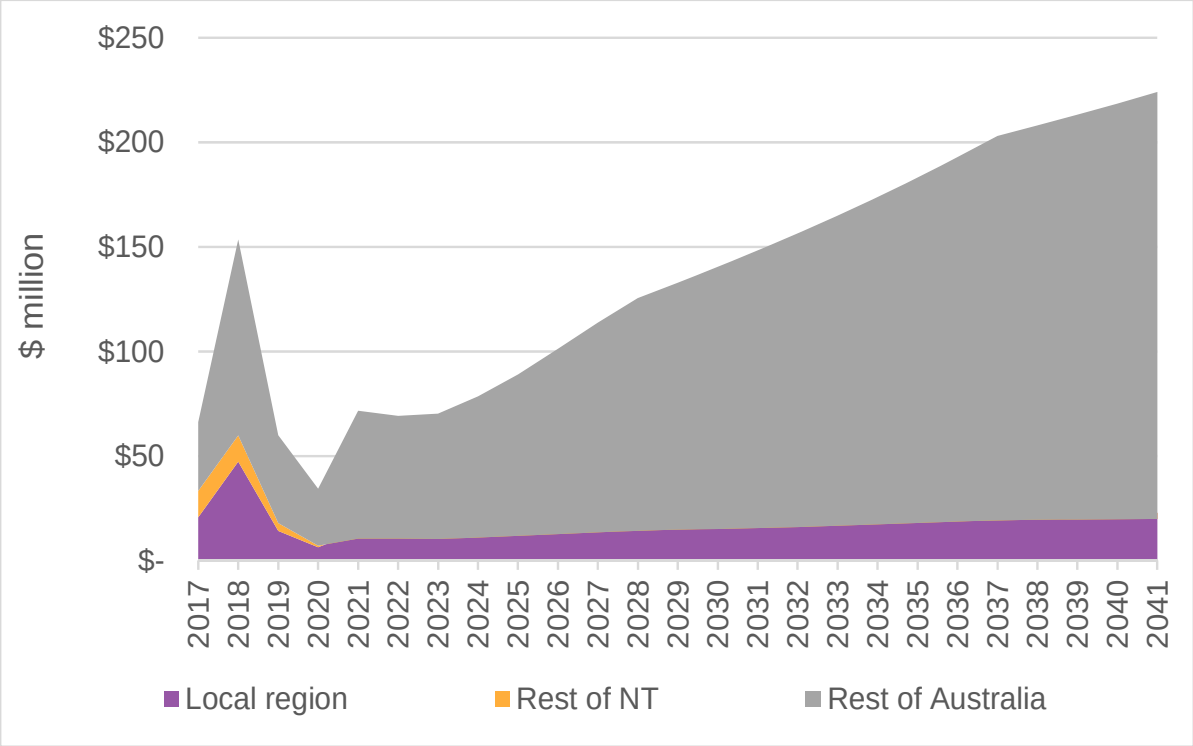
Real income is a measure of the welfare of residents in an economy or the increase in ability to purchase goods and services and to accumulate wealth. The change in real income from a development is a measure of the change in welfare of an economy.

Almost $3.4 billion would be contributed to the real incomes of Australians over the life of the Proposal. This includes an increase of $441 million to real incomes in the NT. The contribution to the local region would be higher at $476 million for the life of the Proposal (refer to Table 12-8 and Figure 12-16).

The reason that the majority of the impact on real incomes is realised in the rest of Australia is that only a small portion of the Proposal is assumed to be owned by local residents of the NT, with a significant portion of the wealth generated by the economic activity transferred outside of the local region and the NT to shareholders who are assumed to be evenly disbursed across Australia. In addition, the distribution of federal taxes generated by the Proposal is assumed to primarily occur in the rest of Australia.

Table 12-8 Projected cumulative change in real income

Location	Real income		
	Total (2017 to 2041)	Net present value	
		4%	7%
	2016 A$m	2016 A$m	2016 A$m
Local region	475	295	220
Rest of NT	-35	-10	-0
Rest of Australia	2,950	1,615	1,090
Total NT	**440**	**285**	**220**
Australia	**3,390**	**1,900**	**1,310**



12.4.5 Job creation

Construction and operation of the Proposal would result in both direct and indirect employment. Direct employment is the number of workers directly employed by the Proposal. Indirect employment is the number of workers employed as a result of additional spending in the local economy by the Proposal.

Direct employment

Over the construction period it is expected that 1,299 full time equivalent workers would be employed. At peak construction there would be a full time equivalent workforce of around 720 workers (refer to Section 12.4.2). Around 477 workers (or 37 % of the construction workforce) would be sourced from the local region. In total, about 940 workers (or 72 % of the construction workforce) would be sourced from the NT (including the local region) and the remaining 360 workers (or 28 % of the construction workforce) would be sourced from the rest of Australia.

During steady state operations it is expected that 150 full time equivalent workers would be employed at the proposed Chandler Facility and Apirnta Facility (refer to Section 12.4.2). Ninety jobs (or around 60% of the operational workforce) would be sourced from the local region. In total, it is expected that nearly 128 workers (85% of the operational workforce) would be sourced from the NT and the remaining 22 workers (15% of the operational workforce) would be sourced from the rest of Australia.

Total (direct and indirect) employment

Just over 5,400 full time equivalent job years would be created over the life of the Proposal, an average of 217 full time equivalent job years per annum (refer to Table 12-9).

The Proposal would deliver long term job creation in Australia, particularly in the NT where most of the job creation would be realised. An estimated 3,600 full time equivalent job years would be created in the NT over the life of the Proposal. This is equivalent to an average of 146 full time equivalent job years per annum. Around 2,600 of these or an average of 100 per year would be located in the local region. This equates to 30 % of the current number of unemployed people in the Alice Springs Local Government Area or 18 % of the unemployed people in the local region (refer to Table 12-9 and Figure 12-17).

Table 12-9 Direct and indirect job creation (construction and operation)

Location	Total (2017-2041)	Annual average (2017-2041)
Local region	2,596	104
Rest of NT	1,072	43
Total NT	3,665	71
Australia	5,430	217

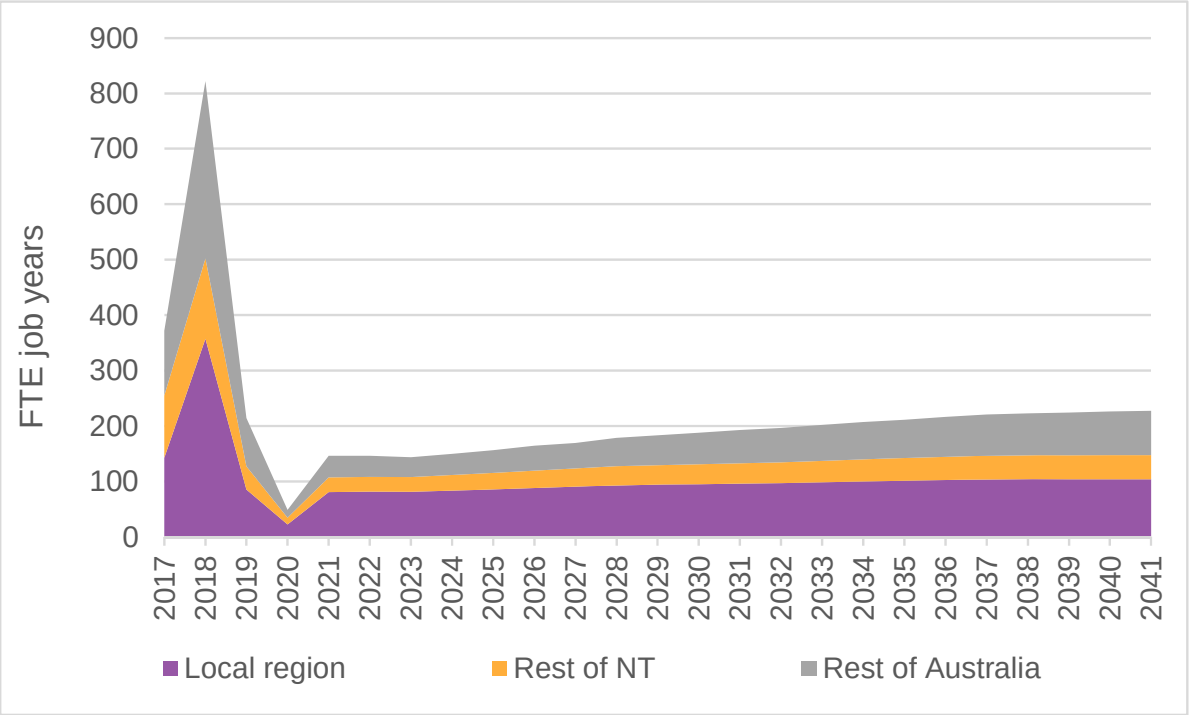


Figure 12-17 Employment creation (construction and operation)

12.4.6 Contribution to government revenue

Over $165 million in wages would be paid during the four years of construction of the Proposal. Just over $540 million in wages in Australia would be paid over the life of the Proposal. Assuming no deductions, these payments would result in estimated payroll taxation payments to the NT Government during the construction and operation of the Proposal in the order of $29 million or an average of just over $1.1 million in each year of the modelled life of the Proposal.

Almost $1.9 billion in direct and indirect taxation would be paid over the life of the Proposal (or an average of around $75 million each year over 25 years). The majority of this taxation would be in the form of company taxes paid by the proponent as well as other personal and company income taxes paid to the Federal Government (refer to Table 12-10).

In total, the NT is likely to receive $34 million in payroll taxes as a result of direct and indirect state revenues from the Proposal, or an average of $1.4 million per annum (refer to Table 12-10).

Table 12-10 Cumulative projected change in real government tax revenues, relative to the reference case (A$ Million)

Item	Total (2017 – 2041)	Net Present Value 4%	Net Present Value 7%
Proposal company taxes	$902	$455	$266
NT payroll taxes	$34	$22	$16
Other taxes on income	$599	$358	$242
Other taxes	$344	$207	$141
TOTAL	**$1,879**	**$1,041**	**$664**

12.4.7 Opportunities for regional centres

There would be a significant contribution to regional development that would result during construction and operation of the Proposal. These contributions are summarised below.

Business development

The proponent has made a commitment to support businesses in the local region and in the NT. Examples of the types of local businesses that could be involved during the construction stage include earthmoving and civil engineering companies, trades such as electricians, plumbers and gas fitters, caterers, suppliers of fresh food and household consumables. Local businesses would also have the opportunity to enter into long term agreements to provide goods and services during operation of the Proposal. These would include those businesses that provide cleaning, maintenance, catering, grading, electrical, plumbing and other services.

Local job creation

The proponent has committed to an ongoing target of reducing fly-in-fly out work practices and encouraging drive-in-drive-out work practices from Alice Springs and the surrounding area. This commitment would result in the creation of direct employment opportunities for people living in the local region. In addition, indirect employment would be created via spending in the local economy by the Proposal.

As discussed in Section 12.4.5, around 37% of the construction workforce would be sourced from the local region and during steady sate operations it is expected that around 60% of the operational workforce would be sourced from the local region. This is equivalent to around $61 million per annum in wages in construction and $24 million per annum in wages during steady state operations. It also represents significant opportunities for local job seekers in terms of the skills required in construction and operation. In construction, there would be a large requirement for labourers which would allow local job seekers access to fairly long term, low skilled employment. The operational phase would require a higher level of skills which would have a number of benefits including assisting in attracting skilled workers to the area, providing employment opportunities for skilled job seekers already living in the area, and providing opportunities for local people to upskill. Further detail regarding employment and training is provided in Section 12.4.8.

Population retention

Job creation is expected to increase employment in the local region by an average of 100 full time equivalent years per annum over the life of the Proposal (refer to Section 12.4.5 and Table 12-9). This increase in employment could result in new people moving to the area in the form of workers and their immediate families. It is likely that this population would reside in the Alice Springs Local Government Area which currently has a population of 28,667 and is experiencing population growth of around -0.2% per annum with forecast population growth expected to remain low (NT Government 2015).

Local content estimates for employment and purchases

During construction, there would be a high local content with an estimated 67 % of all construction costs to be spent in Australia. This is equivalent to $436 million of spending in Australia during the four years of construction. Around $231 million or 36 % of the total construction cost would be spent in the NT and 18 % of the total construction cost would be spent in the local region. In the local region, $118 million would be spent during the four years of construction of which nearly $73 million would be spent in 2018, the peak construction year.

During operation, $1.2 billion or 64% of the total operation spend (including labour) would be spent in Australia. A total of 52% of the total cost to operate the Proposal would be spent in the NT and 32% would be spent in the local region. This is equivalent to spending in Australia of over $1.2 billion over the 25 years of the Proposal including just over $1 billion in the NT. Of this, over $600 million would be spent in the local region (an average of $24 million per annum) with the majority of that expenditure expected to be spent in Alice Springs.

Opportunities for indigenous participation

The proponent has committed to sponsorship of sporting and academic programs in the nearby community of Titjikala.

Land use agreements are currently under negotiation with the government and with the Central Land Council. It is anticipated that the land use agreements would generate a range of potential opportunities for businesses in the local region and in the NT in the areas of agribusiness, tourism and conservation including ranger services and cultural and traditional tourism ventures.

There would also be financial commitments to local Aboriginal groups under the *Native Title Act 1993*.

12.4.8 Employment and training

The expected direct and indirect jobs created during construction and operation of the Proposal is discussed in Section 12.4.2 and Section 12.4.5. This section presents the occupational classification of workers that would be directly employed by the Proposal. Indigenous employment, training and the expected level of overseas employment is also discussed.

Occupational classification of workforce

The occupational classification of workers that would be directly hired during construction and operation of the Proposal is provided in Figure 12-18. The most common occupations that would be directly employed during construction include labourers, and technicians and trades workers. Together these two occupations would employ 70 % of the construction workforce, a total of 900 workers. The high share of labourer occupations will be important as they would allow less skilled job seekers access to employment opportunities over a relatively long construction period.

During operation, the required occupations would have a higher skill level than during construction. The most common occupation would be machinery operators and drivers who would account for around 45 % of the workforce, or 70 of the 160 required workers.

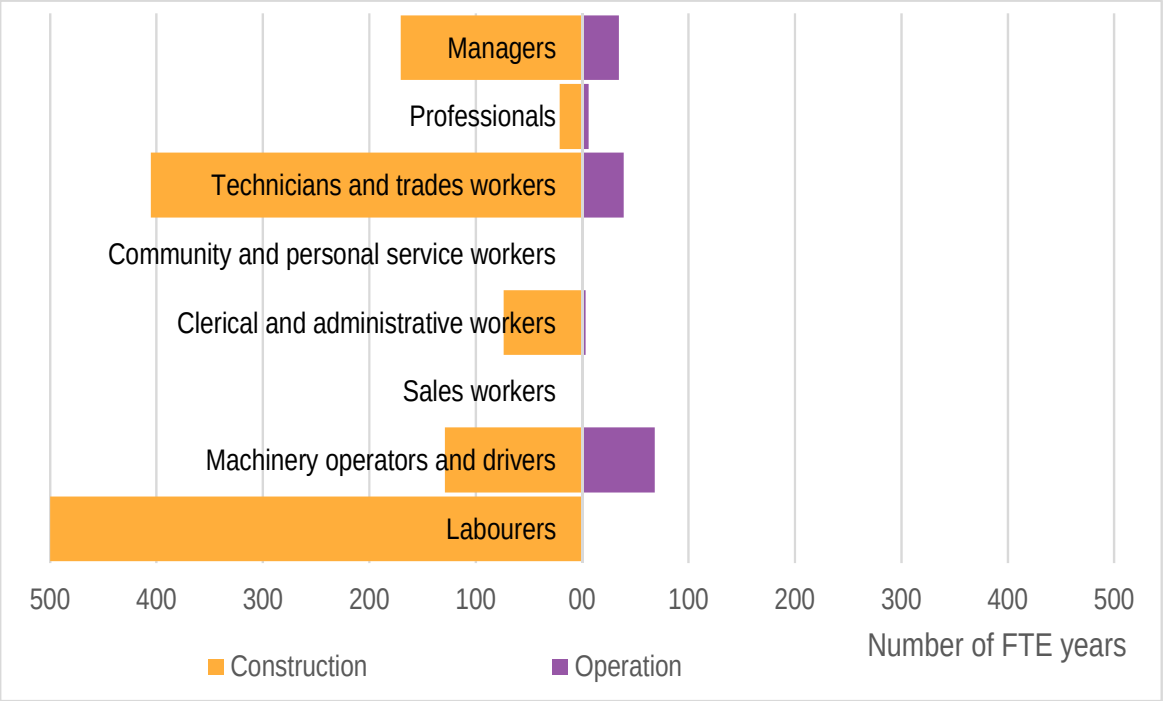


Figure 12-18 Occupational classification of direct workforce

Indigenous employment

The proponent has set a target of 10% indigenous employment sourced from the local region during construction and operation of the Proposal. This is equivalent to an average of around nine indigenous workers in each year of construction and 10 in operation.

Training

Training would be provided for employees in order to provide them with the skills to work in a safe and productive way during the construction and operational phases of the Proposal. This training would focus on trade-related skills, as well as on skills required by the general workforce such as driver training, cultural awareness, occupational health and safety and so on.

Overseas recruitment

The proponent would not actively seek employees from overseas for the construction or operational phases of the Proposal.

12.4.9 Residual infrastructure

Infrastructure that could be used by third parties once the Proposal has reached the end of its operational life include the Chandler Haul Road and Henbury Access Road. The roads would be made available to pastoralists post closure and rehabilitation of the Chandler Facility and Apirnta Facility.

Sections of the existing Maryvale Road would be upgraded as part of the Proposal. These upgrades would benefit users (primarily tourists and local residents) during operation of the Proposal. These upgrades would also benefit users beyond the end of the operational life of the Proposal.

12.4.10 Population

As discussed in Section 12.4.7, job creation is expected to increase employment in the local region. This increase in employment could result in new people moving to the area in the form of workers and their immediate families. It is likely that this population would reside in the Alice Springs Local Government Area. This conclusion is a result of a number of factors including the high level of social and economic services and infrastructure available in Alice Springs and its relative proximity to the Proposal.

Alice Springs currently has a population of 28,667 and is experiencing population growth of around -0.2% per annum with forecast population growth expected to remain low (NT Government 2015). This has resulted in a favourable private housing market which is currently characterised by affordable and available rental and sales properties. Together, these factors make Alice Springs an attractive and affordable place to relocate to.

It is possible that some population would also seek to move to the communities of Santa Teresa, Finke and Titjikala. It is likely that in this event, these people would be Aboriginal people who are returning to country to take up employment opportunities that arise as a direct and indirect result of the Proposal. Given that Titjikala is the closest of these communities to the proposed Chandler Facility, it is reasonable to expect that most people would move to this community, however, family links and other demands may influence potential workers to move to other communities (Santa Teresa and Finke). The likelihood of this occurring is not expected to be great.

12.4.11 Community health and well-being

There would be a positive contribution to community health and well-being (in the form of education and training, business opportunities, and health benefits) that would result during construction and operation of the Proposal. These contributions are summarised below.

Education and training

As discussed in Section 12.4.8, the proponent has set a target of 10% indigenous employment sourced from the local region during construction and operation of the Proposal. This is equivalent to an average of around nine indigenous workers in each year of construction and 10 in operation. This commitment would ensure that, where possible, local people are employed particularly those from the nearby communities of Santa Teresa, Finke and Titjikala where employment opportunities are limited due to their remote locations. This commitment would allow local people to gain skills from education, training and work experience, thereby improving their employment prospects.

The proponent has committed to the sponsorship of academic programs in the nearby community of Titjikala. This would also assist local people in gaining education and employment opportunities.

Business opportunities

As discussed in Section 12.4.7, land use agreements are currently under negotiation with the government and with the Central Land Council. It is anticipated that the land use agreements would generate a range of potential opportunities for businesses in the local region and in the NT in the areas of agribusiness, tourism and conservation including ranger services and cultural and traditional tourism ventures.

Health impacts

There would be health benefits associated with the sponsorship of sporting programs in the nearby community of Titjikala. In addition, long term employment and business opportunities would provide for greater certainty for those people wishing to engage which would have positive mental health and well-being benefits.

There is the potential for road safety issues associated with increased vehicle movements on shared roads as a result of vehicles accessing the proposed Apirnta Facility and Chandler Facility during construction of the Proposal. During operation, a private access and haul road (the Henbury Access Road and Chandler Haul Road) would be used to access the Apirnta Facility and Chandler Facility. These impacts would be mitigated and managed through workplace education programs and through a Traffic Management Plan that would be incorporated into the CEMP, OEMP and RCP for the Proposal.

12.4.12 Culture and way of life

The Southern Arrernte or Pertame people are the Traditional Owners of the land on which the proposed Chandler Facility is located. These Traditional Owners mainly live in the community of Titjikala as well as in Alice Springs and in remote outstations. In addition, there are large populations of Aboriginal people living in the nearby remote communities of Finke and Santa Teresa. There are very few visitors to the area apart from tourists and visitors to Maryvale Station.

There would be very little disruption to the culture and way of life of visitors to the area. There would be some minor impacts from increased vehicle movements along shared roads which would

create impacts in the form of increased road safety risks. There would also be some change to the visual landscape of the area in the form of the construction of the proposed Chandler Facility and its ancillary infrastructure (the proposed Apirnta Facility and the Chandler Haul Road and Henbury Access Road). Visual impacts are discussed in Chapter 17.

Remaining on-country

Employment and business opportunities created by the Proposal and its flow on impacts would assist in allowing Traditional Owners and other Aboriginal people to remain on country or to relocate back to country. This would allow the culture and way of life of these people to continue.

Vehicle movements

There would be some disruption to the culture and way of life of the Traditional Owners of the land on which the proposed Chandler Facility would be located and to the people living in the communities of Finke, Santa Teresa and Titjikala. These impacts would result from increased vehicle movements along shared roads and the construction of the Chandler Facility and its ancillary infrastructure (the proposed Apirnta Facility, Henbury Access Road and Chandler Haul Road). The proponent has been in consultation with Traditional Owners since 2012 in order to minimise disruption during construction, operation and closure and rehabilitation of the Proposal.

Sensitive areas

In consultation with the Traditional Owners, several sensitive areas have been identified which have designated as cultural heritage exclusion zones within the vicinity of the proposed Chandler Facility. These areas (and their exclusion zones) have been cleared with the Central Land Council. These areas would be avoided during construction, operation, and closure and rehabilitation of the Proposal.

Further discussion of cultural heritage is provided in Chapter 10.

12.4.13 Social infrastructure and services

The impact on social infrastructure and services such as health, emergency services and housing in the local region has been assessed as a result of the direct impact of the Proposal. It is predicted that the majority of impacts on social infrastructure from the Proposal would be realised in Alice Springs. The impact on the social services and infrastructure in Alice Springs is predicted to be minimal given the capacity of the social infrastructure in the town. These impacts are discussed below.

Health services

Medical personnel would be stationed within the accommodation village in the area of the proposed Chandler Facility. In the event that staff require further medical assistance, they would be transported by road to Alice Springs Hospital or evacuated by the Royal Flying Doctor Service. Medical facilities in the towns of Santa Teresa, Finke and Titjikala would not be used during construction, operation, or closure and rehabilitation of the Proposal.

Emergency services

Emergency response facilities would be established on-site to enable an appropriate, fast response in the event of an emergency such as a fire or hazardous spill. These facilities would include emergency communication devices, firefighting equipment and spill clean-up equipment. An emergency phone system would also be established. The system would be independent of power and communications systems in order to remain functional in the unlikely event of a breakdown. The emergency response facilities would be situated at both at the proposed Chandler Facility and Apirnta Facility.

The Chandler Haul Road would also be appropriately designed to allow for light aircraft (operated by the Royal Flying Doctors Service) to land on-site in the event of a medical emergency. The section of road would be designed to relevant standards for remote airstrips, including those specified by the Royal Flying Doctors Service.

Given the above, it is unlikely that outside emergency services would be required at the proposed Apirnta Facility or the Chandler Facility. However, the closest emergency services that may be required for assistance in the event of an emergency situation are those located in Alice Springs.

Housing market

If there is an increase in the population of Alice Springs as people move to the town to take up work opportunities created by the Proposal, there could be some pressure in the availability and affordability in the private housing market within the Alice Springs Local Government Area. This situation could result in some tenants being displaced from the private housing market which would put further stress on the public housing market. This probability is expected to be low as the situation in the current private housing market suggests that there would be little impact of the Proposal on the availability and affordability of private housing unless there is a cumulative impact from other developments. Cumulative impacts are discussed in Chapter 19.

Whilst no official statistics are available regarding the housing market in Santa Teresa, Finke and Titjikala, the Central Land Council noted that housing in remote areas governed by the Council is a key issue for people living in these communities because of critical shortages and overcrowding problems. Any increase in population in these communities is, therefore, likely to add to housing stress.

12.5 Assessment of impacts during closure and rehabilitation

Closure and rehabilitation would require the employment of people in specialist areas of mine closure and rehabilitation. While this would see a reduction in employment numbers, the long term annuity of employment over the 25 plus years operating life is considered to outweigh any impact of jobs being reduced to meet the requirements during closure and rehabilitation of the Proposal.

12.6 Assessment of risk during construction, operation and closure and rehabilitation

There are a number of economic and social benefits that would be created by the direct and indirect spending in the local region required during construction and operation of the Proposal. These benefits have been described in detail in Section 12.4 and in Appendix U.

It is possible that the proposed level of spending in the local region would not be able to be achieved in the event that goods and services, including labour, is not available. In this case, goods and services would have to be purchased from elsewhere and the social and economic benefits highlighted herein may not be fully realised. This risk, however, is considered to be low. The local region includes the town of Alice Springs which is the key population and service centre in central Australia. It is a modern town with a good level of social infrastructure and it supports a large population. It also supports a large number of business which service the local population and the surrounding region including the construction industry and the resources sector. The high level of social and economic infrastructure and experience in the construction industry and the mining sector would indicate that the town is well equipped to provide the goods and services, including labour, required for construction and operation of the Proposal.

Alice Springs should be able to absorb an increase in demand for goods and services even if other developments come online at the same or similar times as the Proposal (refer to Chapter 19). Furthermore, the tight labour market in the town could result in additional people moving to Alice Springs to take up job opportunities offered by the Proposal and other proposed developments which would serve to boost the economy of Alice Springs.

12.7 Mitigation and monitoring

Mitigation and management measures proposed to minimise economic and social impacts are listed in Table 12-11. These measures would be incorporated into a CEMP, OEMP and/or RCP for the Proposal. A draft Social Impact Management Plan has also been prepared for the Proposal (refer to Appendix U).

Table 12-11 Mitigation and management measures (economic and social)

ID	Outcome	Mitigation/management measure	Timing
ES.1	Management of expectations and maintenance of good working relationship with stakeholders.	Continue to engage in stakeholder consultation to inform stakeholders of forced or unpredicted delays. In particular, work with the NT Chamber of Commerce, the NT Government and the Industry Capability Network through the progression of the Proposal.	Pre-construction and construction
ES.2	High local content during construction and operation	Commit to spending in the local region. Spending would directly benefit local businesses and their employees. It would also indirectly benefit other businesses in the local region through	Construction and operation

ID	Outcome	Mitigation/management measure	Timing
		the spending on goods and services by these businesses.	
ES.3	Direct employment opportunities during construction and operation	Commit to local employment. Provide opportunities to gain experience in construction and also long term work experience during operation.	Construction and operation
ES.4	Creation of opportunities for indigenous people from the local region to gain long term employment in a new industry	Set target of 10% indigenous employment from the local region during construction and operation.	Construction and operation
ES.5	Creation of opportunities for employment of local people as well as indirect opportunities from flow on impacts	Commit to local employment. This would increase job creation within the local region and NT.	Construction and operation
ES.6	Creation of large economic flow on impact from the Proposal. Some drawing of resources away from the rest of the local region and NT.	Commit to spending and employment in the local region. This would increase the economic value created in the local region and in the NT.	Construction and operation
ES.7	Increase in the ability of local people to purchase goods and services and to accumulate wealth.	Commit to local employment.	Construction and operation
ES.8	Boost to payroll taxation in the NT	Commit to local employment. This would increase revenue from payroll taxation.	Construction and operation, and closure and rehabilitation
ES.9	Minimisation of stress on housing market (however there would be a low risk of impacting this market).	Commit to maximise the use of drive in – drive out employment over fly in – fly out employment which may encourage additional population to Alice Springs.	Construction and operation, and closure and rehabilitation
ES.10	Increased demand for goods and services through direct and indirect spending in the local region and NT.	Commit to local spending and employment as well as commit to ongoing consultation with local business organisations and government to maximise benefit to NT.	Construction and operation, and closure and rehabilitation
ES.11	Opportunities for new and existing businesses (e.g. agribusiness, tourism and conservation including ranger services and cultural and traditional tourism ventures) to support the Proposal	Execute land use agreements with relevant parties. Land use agreements would generate a range of potential business opportunities for businesses in the local region and in the NT.	Pre-construction
ES.12	Opportunities for education and training of local people, in addition to new business opportunities for local businesses involved in the education and training sector	Develop a Workforce Management Plan. Measures included in the plan would include a commitment to conduct training for employees in the local region and to also source training providers from the local region.	Pre-construction

ID	Outcome	Mitigation/management measure	Timing
ES.13	Benefits to local road users including tourists from residual road infrastructure (including the Henbury Access Road, Chandler Haul Road and upgrades to Maryvale Road)	Ensure Henbury Access Road and Chandler Haul Road are made available to pastoralists post closure and rehabilitation of the Proposal.	Closure and rehabilitation
ES.14	Positive health and education impacts within the local region	Commit to the sponsorship of sporting and academic programs within the community of Titjikala.	Construction and operation, and closure and rehabilitation
ES.15	Reduced impacts from increased vehicle movements on Maryvale Road, Chambers Pillar Road, Stuart Highway	Commit to workplace programs regarding road safety and develop and implement a Traffic Management Plan.	Pre-construction, construction and operation, and closure and rehabilitation
ES.16	Protection of culturally important sites	Maintain and respect cultural heritage exclusion zones. Continue consultation with Traditional Owners and nearby residents throughout the life of the Proposal.	Construction and operation, and closure and rehabilitation
ES.17	Some interaction between workers and local residents possible, but unlikely.	House workers in accommodation village. Maintain strict workplace regulations which minimise interaction with local residents and promote responsible behaviour.	Construction and operation, and closure and rehabilitation

12.8 Summary of risk assessment

A summary of the risk assessment undertaken for economic and social during construction, operation, and closure and rehabilitation of the Proposal is provided in Table 12-12.

Table 12-12 Summary of risk assessment (economic and social)

Hazard	Pre-mitigated risk			Post-mitigated risks			Risk outcome
	Likelihood	Consequence	Risk ranking	Likelihood	Consequence	Risk ranking	
Community acceptance of the Proposal (Titjikala)	Possible	Major	High	Remote	Moderate	Low	Risk reduced
Community acceptance of the Proposal (Alice Springs)	Likely	Major	High	Unlikely	Moderate	Medium	Risk reduced
Regional acceptance of the Proposal (NT/Australia)	Unlikely	Major	Medium	Remote	Moderate	Low	Risk reduced
Not mining salt (no product export)	Eliminated	Insignificant	Eliminated	Eliminated	Insignificant	Eliminated	Risk same
Not mining salt (no product local)	Eliminated	Insignificant	Eliminated	Eliminated	Insignificant	Eliminated	Risk same
Not mining salt (tourism)	Eliminated	Insignificant	Eliminated	Eliminated	Insignificant	Eliminated	Risk same

Not mining salt (employment)	Eliminated	Insignificant	Eliminated	Eliminated	Insignificant	Eliminated	Risk same
Not mining salt (royalties)	Eliminated	Insignificant	Eliminated	Eliminated	Insignificant	Eliminated	Risk same
Employment opportunities - construction	Almost certain	Major	Extreme (beneficial opportunity)	Almost certain	Major	Extreme (beneficial opportunity	Risk same
Employment opportunities - operations	Almost certain	Major	Extreme (beneficial opportunity	Almost certain	Major	Extreme (beneficial opportunity	Risk same
Employment opportunities - ancillary employment	Almost certain	Moderate	High (beneficial opportunity	Almost certain	Major	Extreme (beneficial opportunity	Risk improved

12.9 Conclusion

There would be a significant benefit to the economy of the local region, the NT and to the economy of Australia as a result of the Proposal. There would also be significant social benefits associated with the Proposal.

The capital expenditure is estimated to be around $676 million for the Proposal. The construction period would have a high local content - around 67 % of all construction costs would be spent in Australia (36 % spent in the NT). Over the construction period it is expected that 1,299 full time equivalent workers would be employed (all sourced from within Australia). Around 477 workers (or 37% of the construction workforce) would be sourced from the local region. In total, about 940 workers (or 72% of the construction workforce) would be sourced from the NT (including the local region) and the remaining 360 workers (or 28% of the construction workforce) would be sourced from the rest of Australia.

Operation would occur concurrently with construction. On average, there would be spending of just under $81 million per annum to operate the Proposal. Of this, 64 % would be spent in Australia (a total of 52 % would be spent in the NT, 32 % of which would be spent in the local region).

The local region would benefit significantly from the Proposal. Around $118 million of capital expenditure would be spent in the region during construction and an average of $26 million per annum in operation. Local employment would receive a boost with 477 construction workers sourced from the region and an average of 90 full time equivalent workers per annum in operation.

The gross domestic product of Australia would rise by about $4.1 billion or an average of $166 million each year over the life of the Proposal. Most of this impact would be realised in the NT (the majority of which in the local region). About $3.6 billion (or an average of $144 million per year) would be added to the gross state product of the NT over the life of the Proposal. This would result in a significant annual contribution to the gross state product of the NT and is equivalent to around 0.6% of the current gross state product of $23.1 billion.

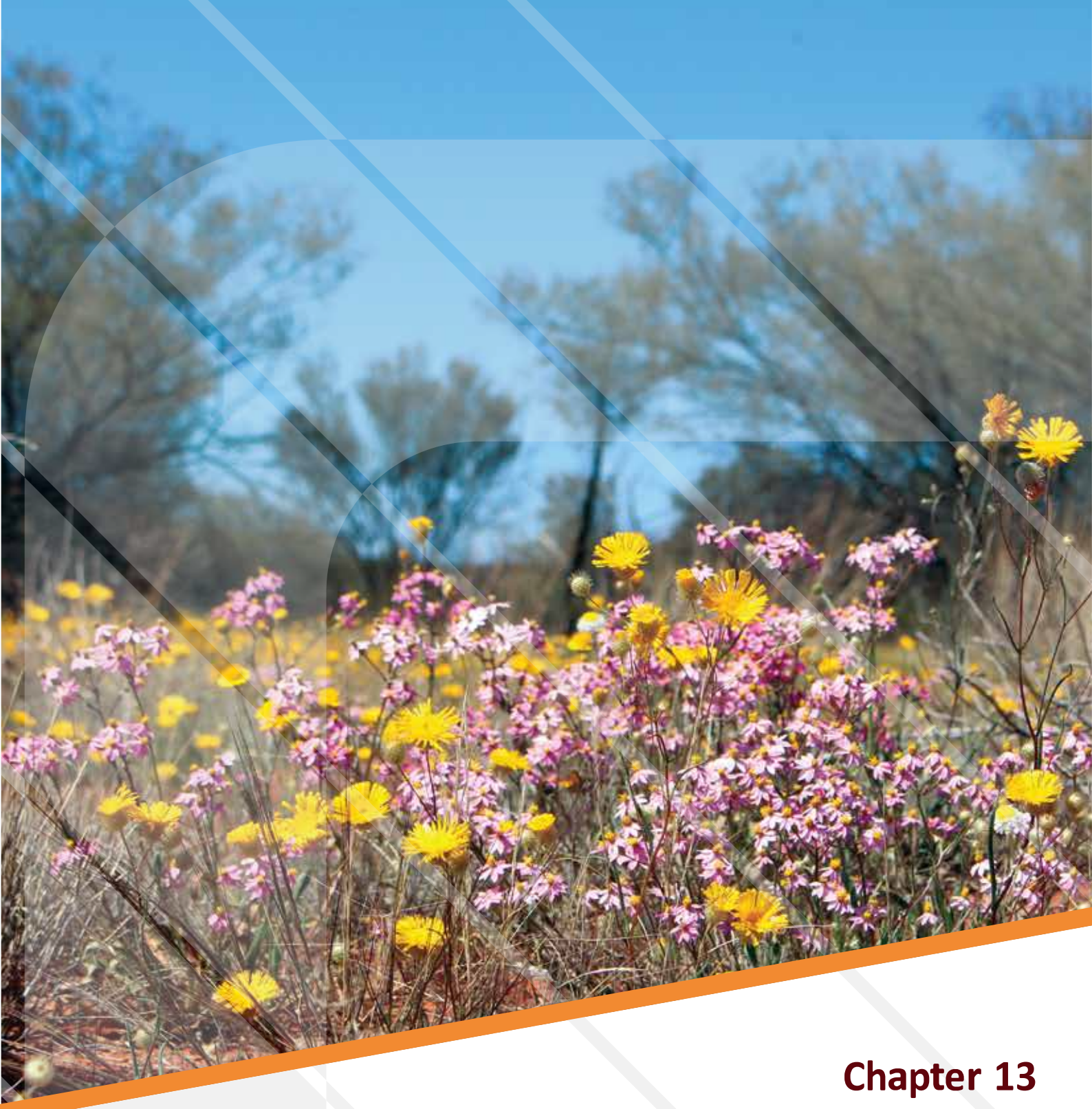
Almost $3.4 billion would be contributed to the real incomes of Australians over the life of the Proposal. This includes an increase of $441 million to real incomes in the NT. The contribution to the local region would be higher at $476 million for the life of the Proposal.

Job creation would be significant. Over the construction period it is expected that 1,299 full time equivalent workers would be employed. During steady state operations it is expected that 150 full time equivalent workers would be employed by the Proposal. Just over 5,400 full time equivalent job years would be created over the life of the Proposal, an average of 217 full time equivalent job years per annum. The Proposal would deliver long term job creation in Australia, particularly in the NT where most of the job creation would be realised. An estimated 3,665 full time equivalent job years would be created in the NT over the life of the Proposal. This is equivalent to an average of 71 full time equivalent job years per annum.

Almost $1.9 billion in direct and indirect taxation would be paid over the life of the Proposal (or an average of around $75 million each year). The majority of this taxation would be in the form of company taxes paid by the proponent as well as other personal and company income taxes paid to the Federal Government. In total, the NT is likely to receive $34 million in payroll taxes as a result of direct and indirect state revenues from the Proposal, or an average of $1.4 million per annum.

In addition to the modelled economic benefits, there would be other social benefits (particularly to the local region) during construction and operation of the Proposal. These benefits include the creation of new employment opportunities for local job seekers and new business opportunities for businesses wishing to support the Proposal. These opportunities would assist in retaining and attracting people to the local region and particularly to the town of Alice Springs. This would aid in addressing the current population decline in the local region and in Alice Springs.

Indigenous people would have a number of opportunities as a result of the Proposal. The proponent has set a target of 10% indigenous employment as well as other commitments that would benefit local indigenous people such as the sponsorship of sporting and academic programs in the nearby community of Titjikala. Land use agreements are currently under negotiation with the government and with the Central Land Council. It is anticipated that the land use agreements would generate a range of potential opportunities for businesses in the local region and in the NT in the areas of agribusiness, tourism and conservation including ranger services and cultural and traditional tourism ventures. There would also be financial commitments to local Aboriginal groups under the *Native Title Act 1993*.



Chapter 13

Closure and Rehabilitation

This page has been left intentionally blank

13 CLOSURE AND REHABILITATION

13.1 Introduction

This chapter addresses additional risks identified by the proponent and by the NT EPA that may arise during closure and rehabilitation of the Proposal. The assessment of potential impacts resulting from the Proposal was undertaken using the risk assessment approach described in Chapter 6. The Proposal's rehabilitation strategy is described and mitigation and management measures are identified to reduce potential impacts. A draft Rehabilitation and Closure Plan is provided in Appendix J. This chapter has been prepared in accordance with the Terms of Reference (refer to Appendix A).

13.2 Methodology

A qualitative risk assessment has been undertaken for all aspects of mine and waste facility closure and rehabilitation, 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 (refer to Chapter 6).

13.2.1 Decommissioning techniques

The intent of all decommissioning operations is to achieve the following:

- Isolate and protect all fresh water zones from ingress and egress from surface and subsurface.
- Isolate all hydrocarbon bearing zones.
- Prevent in perpetuity leaks from or into the well.
- Remove surface structures so that the landform can be rehabilitated back to its former use.

Progressive rehabilitation would be undertaken in accordance with requirements from:

- The NT *Mining Management Act*, which requires that mining companies pay a security deposit to provide for the rehabilitation of mineral leases. The deposit depends on the size of disturbed areas. The security bond (insurance) has been calculated by the proponent and would be a key factor in approving the Proposal's Mine Management Plan. The deposit is held by the NT Department of Primary Industry and Resources (DPIR). The deposit can be relinquished once the DPIR has issued a certificate of closure confirming that rehabilitation meets the agreed closure criteria.
- A mining agreement is yet to be reached between the proponent and the Central Land Council. The basis of the future agreement would be dependent on the proponent restoring disturbed areas to a condition that is reasonably compatible with the surrounding environment.

13.2.2 Rehabilitation objectives

Guiding principles for future rehabilitation of the Chandler mine and for all disturbed areas are listed in Table 13-1.

Table 13-1 Guiding rehabilitation principals

Objective	Guiding principal
Agree post-mining land use	Post mining landform should be reseeded with local native tree and shrub species using seeds from the areas of future disturbance.
Stable landform	Where necessary, stabilise slopes or disturbed ground with vegetation cover to prevent erosion and offsite sedimentation.
Pollution events	Contaminated soil would be remediated to prevent runoff and seepage.
Safe for future generations and the environment	• Mine voids would be backfilled using solid waste packaging and/or hydraulic backfill. In addition, mined salt would be used to fill in void spaces between wastes. • All disturbed areas would be stabilised to ensure they are safe for humans and fauna populations. • All hazardous materials would be removed.

13.2.3 Rehabilitation techniques

The following rehabilitation techniques would be adopted:

- Backfilling the mined salt voids with packaged and hydraulic backfill wastes. Any void space in the packaged storage rooms would be filled with fine salt.
- Internal access roads would be filled with salt.
- Backfilling mine shafts with overburden material.
- Contouring surface landforms to pre-mining levels.
- Allow for adequate drainage of surface water.
- Use original topsoil and re-instate to a depth of at least 300 millimetres. Topsoil should be used directly onto rehabilitation areas.
- Revegetation to occur following the installation of topsoil.
- Revegetation to include the use of native species.

13.3 Assessment of risk during closure and rehabilitation

Risks associated with closure and rehabilitation have been assessed throughout the environmental impact assessment chapters (refer to Chapter 7 through Chapter 19). Additional potential risks during closure and rehabilitation are discussed below.

13.3.1 Waste rock and acid mine drainage

Shaft and decline development will involve the removal of overburden which lies above the Chandler salt mining horizon.

Assessment of the overburden lithology was conducted by Tellus (2016) supported by consultant reports (Douglas Partners 2013, 2015) to determine whether the geo-chemical properties of the overburden posed any constraints to rehabilitation or necessitated specific handling and management practices.

Assessment commenced with a review of existing information relating to the geochemical and physical characteristics of overburden materials likely to be generated from the project. This included a review of all available geochemical data from the overburden sequence within a 10 kilometre radius of the proposed facility location. The assessment indicated that the overburden materials, consisting sandstones, siltstones, dolomitic siltstone and minor gypsum could be classified as Non-Acid Forming-Barren (NAF-Barren).

Examination of rock chip samples and core sample collected from the project site confirmed this assessment. The overburden materials have significant excess buffering capacity and considered to be a non-acid forming rock types with excess acid neutralising capacity.

The waste rock is chemically inactive and has no foreseeable detrimental impact to the environment (Atkins 2017).

Waste rock excavated in development will stockpiled and utilised on site for:

- Initial construction activities as common and select fill.
- Ongoing road maintenance.
- Backfilling and sealing if stockpiled material for end of mine closure.

13.3.2 Creation of ongoing environmental, social and/or economic legacy if operations cease ahead of schedule due to unforeseen circumstances, prior to planned closure and rehabilitation

Financial assurance ensures that funds are available to close and rehabilitate a site, regardless of whether the operator remains financially viable. The proponent would provide appropriate financial assurance for the expected closure and rehabilitation costs of the Proposal. The proponent intends on this financial assurance being via appropriate contributions to a security bond that is administered by the DPIR.

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 agencies within the NT Government. Such a financial assurance package would also be considered on a holistic basis with other financial assurances to be provided for the Proposal (e.g. the Institutional Control Period).

13.3.3 Changes in the assumptions used as a basis for the post-closure risk assessment

The assumptions used throughout the environmental impact assessment for the various risks considered (biodiversity, groundwater, surface water, historic and cultural heritage, economic and social, bushfire, air quality, noise and vibration, visual amenity, greenhouse gas emissions and traffic) have been worst case assumptions. Worst case assumptions are conservative and are the most commonly used method of dealing with uncertainty. Using worse case assumptions often overstates environmental impacts.

13.3.4 Natural events including earthquakes, rainfall, fire and flood

This section discusses risks from natural events (earthquakes, rainfall, fire and flood) during closure and rehabilitation of the Proposal.

Earthquakes

The risk of earthquakes during closure and rehabilitation of the Proposal is discussed in Chapter 8 and in Appendix H and Appendix M. The proposed development footprint is located within a tectonically stable plate interior, thousands of kilometres from the nearest tectonic plate boundaries that are characterised by frequent seismicity and on-going intense deformation (refer to Figure 8-19 in Chapter 8). Moreover, there have been no recorded large earthquakes within the immediate vicinity of the Proposal.

In the unlikely event that an earthquake were to occur, the proposed underground storage facility would not be affected significantly, since damaging vibrations from earthquakes occur only at the surface of the Earth. Extensive research undertaken in Japan has established the feasibility of siting geological disposal facilities for high-level radioactive waste at depths comparable to those proposed for the Chandler Facility. This research has shown that seismic vibrations are attenuated rapidly and would be very unlikely to be felt at 850 metres below ground level (the target depth for hazardous waste emplacement at the proposed Chandler Facility) (JNC 2000).

Earthquakes would only be of concern to the safety of a deep geological disposal facility if the moving fault that causes the earthquake were to intersect the facility. Seismic surveys have revealed no faulting within the proposed development footprint or in the vicinity of the Proposal (RPS 2013).

Rainfall

The site is in an arid environment which receives limited rainfall. For example, the total annual rainfall recorded at the Alice Springs Airport weather station (BoM 015590) ranges from 76 millimetres to 782 millimetres (over the 74-year monitoring period), with an annual mean of 283.5 millimetres.

Fire

The risk of bushfire during closure and rehabilitation of the Proposal is discussed in Chapter 14 and in Appendix R and Appendix X.

Mitigation and management measures proposed to reduce the incidence of bushfire during closure and rehabilitation of the Proposal are listed in Table 14-2 (refer to Chapter 14). These measures would include (but would not be limited to):

- Ensuing fuels and other flammable materials are stored appropriately and in accordance with applicable regulations.
- Ensuring bushfire suppression equipment is available on-site.
- Undertaking fuel load assessments annually to assess bushfire potential and the need for pro-active controls, e.g. back burning.
- Creating fire breaks/asset protection zones with reference to prevailing wind directions, highest wind speeds and vegetation types.

Mitigation and management measures to reduce the risk of bushfires during closure and rehabilitation of the Proposal would be developed in consultation with the NT Fire and Rescue Service.

A draft Bushfire Management Plan has been prepared for the Proposal (refer to Appendix R).

Flood

A detailed assessment of flood risk is provided in Chapter 9 and Appendix R of the EIS.

13.3.5 Water supply

Water used during closure and rehabilitation would be sourced from dedicated production bores located within the mine infrastructure area.

13.3.6 Room, shaft or decline seal failure

Geological barrier

A geo-mechanical evaluation of the salt horizon, taking into consideration the time-dependent mechanical behaviour of the Chandler Halite formation, was carried out by implementing appropriate numerical investigations (refer to Appendix K).

The objective of the geo-mechanical studies of the planned Chandler mine was achieved by employing engineering judgement in analysing the results of the geo-mechanical modelling, by making use of established experience and knowledge in utilising appropriate parameters concerning the strength and the constitutive response of the Chandler Halite mining horizon, and by realistically modelling the geometry, the *in situ* geostatic stresses and the boundary conditions that characterise the planned room and pillar mine layout.

The finite difference method was successfully used for the numerical simulation of the Proposal in investigating the development of the subsurface stress concentrations and creep response of the Chandler Halite that surrounds the planned room and pillar mine layout. With respect to the geo-mechanical response of the planned Chandler Facility, a significant element is the Jay Creek

Limestone strata that overlay the Chandler formation, which have an average thickness of more than 250 metres. Provided that no major faults or prevalent systems of significant discontinuities exist, the Jay Creek Limestone will act as an enormous thick plate, with built-in-ends, that is expected to contribute significantly to the stability of the planned excavations (Atkins 2017).

Examination of the distribution of the principal stresses, for the first 23 years, indicates that the minor principal stress is essentially very close to the compressive regime. Consequently, during the first 23 years following the excavation of the panels, the possibility of developing in the roof of the rooms tensile stresses that may exceed the tensile strength of the Chandler Halite is almost unlikely (Atkins 2017). However, the excessive creep closure that has been identified in the roof of the rooms next to edge of the panels will, in all probability, result in the development of tensile cracks.

Calculation of the *Strength Factor* against shear failure for the salt pillars has shown that, even at the early life of the mine, the *Strength Factor* values indicate no shear failure. The identified *Strength Factor* values demonstrate that the Chandler Halite of the pillars, when subjected to the stress concentrations caused by the excavations, is able to endure shear stresses over a period of thirty years.

Moreover, assessment of the distribution of the minor principal stress and the Von Mises stress above the salt mine provided evidence that the 20 metre thickness of salt, which is left between the roof of the rooms and the top of the Chandler Halite, prevents the establishment of a pathway to the biosphere. Essentially, the roof salt above the underground excavations constitutes an adequate barrier that prevents the development of migration paths for potential contaminants (associated with the underground storage operations) towards the non-salt formations.

Practical experience from *in situ* measurements and observations concerning underground openings in salt formations, suggests that the identified order of magnitude of the rates of creep displacements, both along the vertical and horizontal directions, are excessive and they are expected to have a long term negative effect on the serviceability limit state of the underground excavations. The identified rates of room creep convergence are very high, indicating that the roof of the rooms (especially those rooms located near the edges of the panel) may be unstable in the long term.

In summary, the preliminary assessment of the geo-mechanical conditions of the planned Chandler Facility indicates that, although the 15 metre wide rib pillars are expected to accept the high stress concentrations while maintaining their long term stability, the 15 metre width of the roof span of the rooms is considered to be too large and will potentially result in unacceptable creep convergence of the rooms.

It is important of course to take into consideration that the derived preliminary conclusions are based on the use of assumed material parameters for the Chandler Halite which clearly have an effect both on the creep convergence of the rooms and the shear strength of the pillars. Although the assumed material parameters are based on well-established practical experience derived from designing and monitoring underground openings in salt formations, once laboratory test results from the Chandler Halite will be made available, there will be a need to re-evaluate the investigated geo-mechanical conditions.

Taking into consideration that the 15 metre width of the roof span of the rooms is considered to be too large, it is recommended to undertake a series of parametric studies to determine the maximum permissible roof span that will provide the requisite long term stability while satisfying the requirements of the serviceability limit state.

Engineered barrier

Once a decision has been taken to permanently dispose of waste fine salt will placed around the waste packages using a "snow blower" type machine to fill any voidage present. This fine salt will re-constitute around the waste packages over time due to the self-healing nature of rocksalt and the surrounding strata converging back in a controlled manner into the opening created by mining, this process is known as salt creep.

After loose salt backfilling has been completed an engineered seal or wall will be constructed at the entrance to the disposal room to permanently isolate the wastes. During the next phases of the project and particularly when operations commence further work will be undertaken to determine the appropriate room seal designs for Chandler but there are many examples of such seals in operation in evaporite mines around the world.

Underground storage and disposal rooms will have been progressively sealed during operations at the point when materials have been deemed not to have any further potential use. At the point of closure of the overall facility the remaining access roadways will be backfilled with salt and engineered seals will be placed in the shaft to control any potential pathway into the underground working.

The precise position and design of these seals will be determined during future work stages but it would be normal to include major seals towards the bottom of the shafts and decline above the salt horizon and adjacent to any aquifers encountered in the shafts. This is a well proven process and technique in similar repositories to Chandler which operate in Europe.

13.3.7 Accident during surface to underground decommissioning

Potential risks of accidents during the surface to underground decommissioning phase may occur (refer to risk assessment table in Chapter 6). To ensure accidents are avoided and minimised during surface to underground decommissioning, the proponent would administer three primary areas of regulation. They include:

1. Safety.
2. Environment.
3. Resource management (which includes groundwater bore integrity).

Under the *Mining Management Act* and associated Regulations, for a mining operation, the following would be reported to the DPIR (compliance division):

- Accidents involving injury to persons.
- Occurrences (commonly referred to as notifiable incidents for reporting purposes).

13.3.8 Climate change

The risk of climate change impacts with respect to the proposed Chandler Facility is addressed in detail in the Post Closure Risk Assessment provided in Appendix I. The preservation of the salt in the Chandler Formation for approximately 520 million years (during which time there have been profound environmental changes) provides evidence that future climate change would not cause significant environmental changes at the level of the Chandler Facility.

13.3.9 Accidental human intrusion

Accidental human intrusion into the proposed Chandler Facility is addressed in detail in the Post Closure Risk Assessment provided in Appendix I. Inadvertent human intrusion would consist of drilling a borehole into the proposed Chandler Facility. Such human intrusion could cause an increase in the likelihood that humans and ecosystems might be exposed to levels of contamination in excess of groundwater standard and guideline values.

Accidental human intrusion cannot be ruled out entirely, however, the remote geographical location of the Chandler Facility and the lack of any obvious natural resources at the depth of the Chandler Facility make this scenario unlikely. It cannot be assumed that records of the Chandler Facility location and characteristics (e.g. emplaced wastes) will be available to future generations.

However, it is technically demanding to drill boreholes or undertake excavations to the depth of the Chandler Facility. It is a reasonable assumption that any future society with the technical capability to undertake such activities would also undertake prior investigations (e.g. seismic surveys) that would identify the Chandler Facility, thereby enabling intrusion to be avoided.

Surface monuments would be installed after closure and rehabilitation at the site of the proposed Chandler Facility. The purpose of the surface monuments would be to identify the isolation/disposal area and to prevent human intrusion and non-compatible land use in the future. A graphical representation of the type of surface monument that would be erected at the site of the proposed Chandler Facility is presented in Plate 13-1.



Plate 13-1 Graphical representation of surface monument

13.3.10 Final landform

After closure, the land surface within the proposed development footprint would be rehabilitated to as near to pre-existing conditions as possible - no voids or depressions would be left post closure of the Proposal. The creation of a stable landform would involve ripping, grading and the redistribution of topsoil from topsoil stockpiles to mimic the natural landform within the proposed development

footprint. The creation of a stable landform would also require revegetation with native species and reinstatement of pre-existing drainage lines.

Rehabilitation would be guided by a detailed Closure and Rehabilitation Plan (a draft Rehabilitation and Closure Plan is included in Appendix K). Rehabilitation would also be supported through a financial security established under the *Mining Management Act 2001*.

To create the final landform, the techniques described in

13.3.11 Re-vegetation

As discussed above, the creation of a stable landform post-closure would require revegetation with native species (e.g. native grasses and shrubs). Revegetation (and monitoring of revegetation success including the potential effects of weeds) would be undertaken in accordance with a detailed Rehabilitation and Closure Plan (a draft Rehabilitation and Closure Plan is included in Appendix K).

The methodology appropriate for monitoring vegetation post-closure would be based on best industry practice at the time. The method chosen would be repeatable (and auditable) and supported by studies and scientific literature. The methodology would also be discussed with the appropriate regulatory agencies prior to implementation.

Re-vegetation during closure and rehabilitation of the Proposal would be best achieved by conserving top soil in protected locations (low windrows) at the beginning of the project development and any opportunity throughout the life of the mine. These storage mounds can be used as windrows controlling water flow around car parks or lay down areas, etc. Even 20 yr old top soil is better for re-vegetating sites than using subsoil, fertilizer and seed (LES 2017). If topsoil is not available, top soil can be harvested with a grader or front end loader from adjacent areas of the same land form in a mosaic pattern, on the contour, to a depth of about five centimetres and spread over the site being re-vegetated.

Re-vegetation would be undertaken after the site has been decommissioned, cleared, ripped to remediate compacted areas, levelled to match local contours and available top soil spread at a shallow thickness, (up to five centimetres) and tined into the subsoil. If there is concern that seed will not be viable in the top soil, local native seed may be collected over the previous year and broadcast spread over the site at the time of scarifying the top soil.

Low dosage of standard blood and bone or fertiliser rich in nitrogen, phosphorus and potassium may also be spread at the time the seed is spread. This exercise should be completed before the summer rainy period, up till October or November. If dead shrubbery or dried grasses are available to scatter over the re-vegetating sites it will be an advantage.

After a year, the re-vegetating sites would be monitored and compared with adjacent areas to assess success of the re-vegetation. If adequate rainfall has occurred and there are holes in the distribution of vegetation due to inadequate soils, more intensive effort to re-vegetate these areas can be undertaken using additional mature seed and fertiliser raked into the soil. Correcting any run-off problems should also be undertaken at this time.

Collection of native grasses, shrubs and tree seeds should be undertaken a year or so ahead of closure to allow seed to mature. Seed should be collected from the local area or plants which are growing in similar land forms to those that are being re-vegetated. Seed should be stored in paper bags in air conditioned premises. Planting of root stock nursery plants is not normally appropriate for these conditions, but may have occasional specialised need

13.3.12 Final land use

The same or similar land use capabilities would exist after closure and rehabilitation to those that existed prior to the development of the Proposal. Land use would be restricted to pastoral (grazing) through a covenant unless other beneficial land uses are pre-determined and agreed upon with the NT Government.

13.4 Mitigation and monitoring

Mitigation and management measures proposed to minimise impacts during closure and rehabilitation of the Proposal are listed in Chapter 7 through Chapter 19. Additional mitigation and management measures proposed to minimise impacts during closure and rehabilitation of the Proposal are listed in Table 13-2. These measures would be incorporated into a RCP. A draft RCP has been prepared for the Proposal (refer to Appendix J).

Table 13-2 Mitigation and management measures (closure and rehabilitation)

ID	Outcome	Mitigation/management measure	Timing
CR.1	Return of the development footprint to near original condition.	Adopt the principles set out in the draft RCP (refer to Appendix L). Such principals would include (but would not be limited to): • Decontaminate structures (if necessary) and wash down prior to the commencement of demolition works. • Determine safe and efficient dismantling procedures and prepare a demolition plan. • Pull structures to ground and dismantle. • Break down concrete slabs and footings to a depth of one metre below the finished ground surface. • Remove or bury services at a depth of at least one metre below the final ground surface. • Leave buried pipes *in situ* and flush and seal each end. • Dispose of non-recyclable and inert waste in an on-site landfill, or similar. • Ensure access roads required to be left for post closure monitoring purposes are defined and retained.	Closure and rehabilitation

ID	Outcome	Mitigation/management measure	Timing
		All areas are ripped to break compaction prior to overburden and/or topsoil application.	
CR.2	Monitoring of rehabilitation and annual reporting on performance and objectives	Undertake monitoring of rehabilitation (including vegetation regrowth) and annual reporting on performance and objectives. Includes monitoring of vegetation regrowth and surface water and groundwater monitoring as per the requirements of the Water Management Plan (refer to Appendix O).	Closure and rehabilitation
CR.3	Maintenance works/remedial action taken, if needed.	Should visual inspections or monitoring results indicate the need for maintenance works or remedial action to be undertaken, mobilise contractors to site to undertake these works. Works may include: • Vegetation – if rehabilitation is failing, additional application of fertiliser, additional seeding or planting may be required. • Erosion - if significant erosion is identified or rehabilitation is not progressing towards a self-sustaining community, the following remedial actions may be considered: o Construct, improve, or repair drainage control measures to reduce water movement down outer slopes of the landform. o Remediate areas of deep erosion and/or instability with appropriate material. • Access - remedial works would be required if access prevention measures fail to restrict unauthorised access.	Closure and rehabilitation
CR.4	Notification of accidents	Any one of the following events would become a notifiable incident: • Extensive subsidence, settlement or fall of ground or any major collapse of any part of the operations of a mine, or any earth movement caused by a seismic event. • Outbreak of fire above or below ground in any mine. • Breakage of a rope, cable, chain or other gear by which persons are raised or lowered. • Inrush of water from old underground operations or other sources. • Accidental ignition of dust below ground; The discovery of the presence of potentially harmful or asphyxiant gas, or an outburst of such gas in any part of a mine.	Closure and rehabilitation

ID	Outcome	Mitigation/management measure	Timing
		• Accidental ignition or detonation of explosives, or any delayed or fast ignition of explosives. • Explosion or bursting of compressed air receivers, boilers, or pressure vessels. • Every electric shock or burn to a person and every dangerous occurrence involving electricity. • Incidence of a person being affected by poisoning or exposure to toxic gas or fumes. • Loss of control of heavy earth-moving equipment, including failure of braking or steering.	

13.5 Summary of risk assessment

A summary of the risk assessment undertaken for closure and rehabilitation of the Proposal is provided in Table 13-3.

Table 13-3 Summary of risk assessment (closure and rehabilitation)

Hazard	Pre-mitigated risk			Post-mitigated risks			Risk outcome
	Likelihood	Consequence	Risk ranking	Likelihood	Consequence	Risk ranking	
Room seal failure	Possible	Minor	Medium	Remote	Minor	Low	Risk reduced
Accident during surface to underground decommissioning	Remote	Catastrophic	Medium	Remote	Catastrophic	Medium	Risk same
Shaft seals fail	Remote	Major	Medium	Eliminated	Moderate	Eliminated	Risk reduced
Decline seals fail	Remote	Insignificant	Low	Eliminated	Insignificant	Eliminated	Risk reduced
No surface remediation (environmental)	Unlikely	Minor	Low	Remote	Minor	Low	Risk reduced
No surface remediation	Unlikely	Major	Medium	Remote	Major	Medium	Risk reduced
No groundwater monitoring	Remote	Moderate	Low	Remote	Minor	Low	Risk reduced
No gas monitoring is undertaken	Remote	Minor	Low	Eliminated	Minor	Eliminated	Risk reduced
No institutional control period monitoring	Possible	Moderate	Medium	Unlikely	Minor	Low	Risk reduced
Future land uses (other land grazing)	Remote	Insignificant	Low	Eliminated	Insignificant	Eliminated	Risk reduced
Earthquakes	Remote	Insignificant	Low	Remote	Insignificant	Low	Risk same
Climate change	Possible	Insignificant	Low	Possible	Insignificant	Low	Risk same
Human intrusion	Remote	Minor	Low	Eliminated	Minor	Eliminated	Risk reduced

13.6 Conclusion

Risks associated with closure and rehabilitation have been assessed throughout the environmental impact assessment chapters (refer to Chapter 7 through Chapter 19). Additional potential risks during closure and rehabilitation include:

- **Creation of ongoing environmental, social and/or economic legacy if operations cease ahead of schedule due to unforeseen circumstances, prior to planned closure and rehabilitation.** To avoid these risks, the proponent would provide appropriate financial assurance for the expected closure and rehabilitation costs of the Proposal.
- **Changes in the assumptions used as a basis for the post closure risk assessment.** Worst case assumptions were used throughout the environmental impact assessment for the various risks considered. Worst case assumptions are conservative and the most commonly used method of dealing with uncertainty (and often overstate environmental impacts)
- **Natural events including earthquakes, rainfall, fire and flood.** The proposed development footprint is located within a tectonically stable plate interior and there have been no recorded large earthquakes within the immediate vicinity of the Proposal. In the unlikely event that an earthquake were to occur, the proposed underground storage facility would not be affected significantly, since damaging vibrations from earthquakes occur only at the surface of the Earth.

  The potential for rainfall and flooding delaying or disrupting closure and rehabilitation activities has been assessed as having low risk. The continual monitoring of rainfall at the Chandler and Aprinta Facilities is recommended to determine annual average monthly rainfall. During months with higher average rainfall, it is recommended to avoid undertaking large scale closure and/or rehabilitation works.

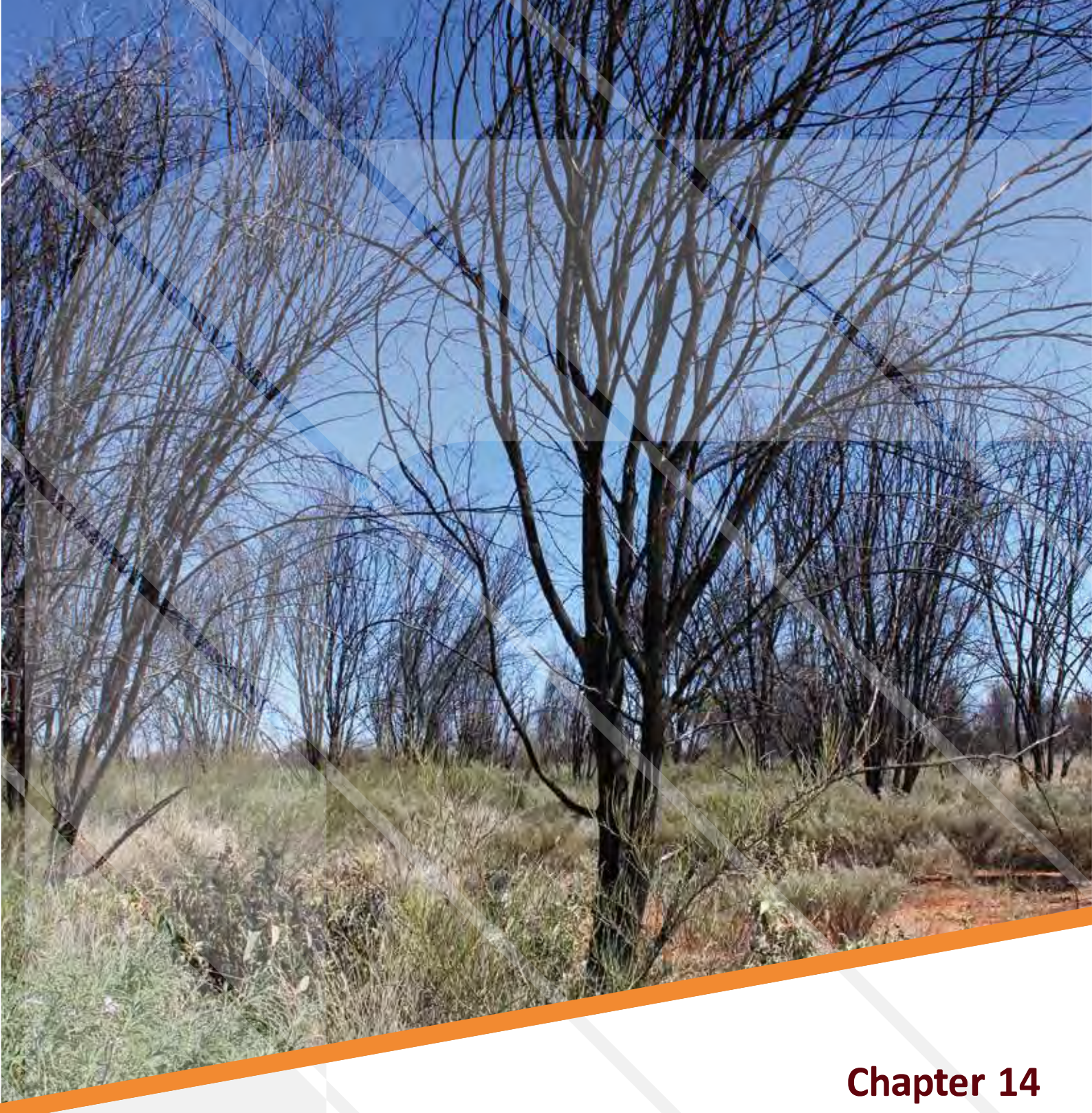
  The risk of bushfire would be mitigated by ensuring fuels and other flammable materials are stored appropriately on-site; ensuring bushfire suppression equipment is available on-site; undertaking annual fuel load assessments to assess the potential need for pro-active controls (e.g. back burning); and creating fire breaks/asset protection zones.
- **Water supply.** Water used during closure and rehabilitation would be sourced from a dedicated production bore located within the mine infrastructure area.
- **Room, shaft or decline seal failure.** The geological and geotechnical properties of the Halite Formation has been quantitatively and qualitatively assessed (Atkins 2016). Spontaneous roof collapse is regarded as having low risk. However, recommendations have been made by Atkins (2016) to reduce the width of the current design of the waste emplacement rooms (currently 15 metres wide). The proponent is committed to undertaking further geotechnical drilling and analysis of the Chandler Halite Formation. During the next phases of the project and particularly when operations commence further work will be undertaken to determine the appropriate room, shaft and decline seal designs for the proposed Chandler facility. Sealing of evaporite mines is well proven process and

technique in similar repositories to Chandler which operate in Europe and elsewhere in the world.

- **Accident during surface to underground decommissioning**. With appropriate management measures in place, the risks of accidents occurring during surface to underground decommissioning are reduced. However, the proponent has identified three key areas of governance for this stage of work (see above). In addition, the proponent has identified the different types of accidents that may occur and be notifiable under the NT *Mining Management Act* and associated Regulations.
- **Climate change.** The preservation of the salt in the Chandler Formation for approximately 520 million years (during which time there have been profound environmental changes) provides evidence that future climate change would not cause significant environmental changes at the level of the Chandler Facility.
- **Accidental human intrusion.** Inadvertent human intrusion would consist of drilling a borehole into the proposed Chandler Facility. It is technically demanding to drill boreholes or undertake excavations to the depth of the Chandler Facility. It is a reasonable assumption that any future society with the technical capability to undertake such activities would also undertake prior investigations (e.g. seismic surveys) that would identify the Chandler Facility, thereby enabling intrusion to be avoided. Surface monuments would be installed after closure and rehabilitation at the site of the proposed Chandler Facility. The purpose of the surface monuments would be to identify the isolation/disposal area and to prevent human intrusion and non-compatible land use in the future.
- **Final landform.** After closure, the land surface within the proposed development footprint would be rehabilitated to as near to pre-existing conditions as possible - no voids or depressions would be left post closure of the Proposal.
- **Re-vegetation**. Revegetation would be undertaken using native species (e.g. native grasses and shrubs). Monitoring of revegetation success, including the potential effects of weeds, would be undertaken post-closure. The methodology for monitoring vegetation would be based on best industry practice at the time.
- **Final land use**. The same or similar land use capabilities would exist after closure and rehabilitation to those that existed prior to the development of the Proposal. Land use would be restricted to pastoral (grazing) through a covenant unless other beneficial land uses are pre-determined and agreed upon with the NT Government.
- Closure and rehabilitation would be undertaken in accordance with the Rehabilitation and Closure Plan that would be finalised following completion of detailed design.



Part F
Assessment of Other Issues



Chapter 14
Bushfire



This page has been left intentionally blank

14 BUSHFIRE

14.1 Introduction

This chapter assesses the potential for an increased incidence of bushfire brought about by the Proposal. This chapter is based on the findings of a bushfire hazard analysis undertaken by the proponent and also draws on a comprehensive terrestrial ecological assessment, which is included as Appendix O. This chapter describes the local climatic conditions, vegetation and bushfire history within the proposed development footprint and vicinity. The potential for an increase in the incidence of bushfires are assessed during construction, operation and closure and rehabilitation of the Proposal. Mitigation and management measures are identified to reduce potential impacts. A draft Bushfire Management Plan is provided in Appendix O.

The bushfire hazard analysis has been prepared in consultation with government departments, pastoralists and Traditional Owners. It has also been prepared in accordance with the Terms of Reference (refer to Appendix A).

14.2 Methodology

The bushfire hazard analysis included a desktop assessment, field investigation, analysis and consultation with Traditional Owners.

14.2.1 Desktop assessment

The desktop assessment included the collation and analysis of:

- Mapping obtained from the North Australia and Rangelands Information website.
- Bushfire prone land by identifying fire scars via satellite imagery and aerial photography flown by the proponent.
- Vegetation, physical relief, tenure, roads and other descriptive features such as aspect, slope, temperature and wind direction.

14.2.2 Field investigations

Extensive field surveys have been undertaken within the proposed development footprint and vicinity over the past four years (between October 2012 and April 2016). The purpose of the field surveys was to document soil types, slope, access and vegetation type and to determine likely constraints with respect to bushfire and the development of the Proposal. Assessments were conducted within and on the boundaries of the following areas:

- The proposed Chandler Facility (including the accommodation village and mine infrastructure area).
- The proposed Chandler Haul Road.
- The proposed Apirnta Facility.

- The proposed Henbury Access Road.

The information recorded in each vegetation type included vascular plant species present, vegetation structure and density, the presence of woody debris and weeds, the impact of disturbance and current vegetation condition.

The above areas were traversed by foot via transect surveys and studied using a GIS.

14.2.3 Consultation

The bushfire hazard analysis was prepared in consultation with government departments, pastoralists and Traditional Owners. The DENR were consulted in order to determine whether the proposed development footprint or vicinity have a specific zoning under the NT Bushfire Regulations. General bushfire mitigation options and recommendations were also discussed considering the results of both the desktop assessment and field investigations. Pastoralists and Traditional Owners were also consulted on issues relating to plants, animals and bushfire history within the proposed development footprint and vicinity.

14.3 Existing environment

This section describes the local climatic conditions, vegetation and bushfire history within the proposed development footprint and vicinity. Fire protection zones are also discussed.

14.3.1 Climate

Climatic conditions influence the risk of bushfires. The highest risk time for bushfires is during periods of low humidity and high temperature. Wind is also an important factor in influencing the direction and speed of a bushfire.

Temperature and humidity

The temperature within the proposed development footprint and vicinity is characterised by distinct hot summers and cold winters, with a wide diurnal range in temperature. Winter months have mean minimum temperatures under 10 degrees Celsius. Summer months have mean maximum temperatures over 30 degrees Celsius.

Air temperatures measured within the proposed development footprint between 5 November 2015 and 31 July 2016 varied between -2.0 degrees Celsius (in winter) and 43.1 degrees Celsius (in summer). The average temperature measured over the year was 24.2 degrees Celsius. Average, maximum and minimum hourly temperatures measured during each season within the proposed development footprint are presented in Table 14-1.

Table 14-1 Observed temperatures - Chandler – 5 November 2015 to 31 July 2016

Season	Temperature (° C)		
	Maximum	Average	Minimum
Annual [*partial*]	43.1	24.2	-2.0
Spring [*partial]*	41.8	31.4	20.7
Summer	43.1	29.9	17.0
Autumn	39.9	24.0	6.3
Winter *[Partial]*	29.3	13.8	-2.0

The daily average temperature along with the observed range in daily temperature calculated between 5 November 2015 and 31 July 2016 is presented in Figure 14-1. As expected, the maximum daily average and maximum temperatures occur during the summer months with a daily average temperature of 29.9 degrees Celsius observed.

Air temperatures during the winter months are, on average, 13.8 degrees Celsius but during the day have reached the high 20 degrees Celsius during the year of measurement. The coldest temperature observed was -2.0 degrees Celsius in winter 2016.

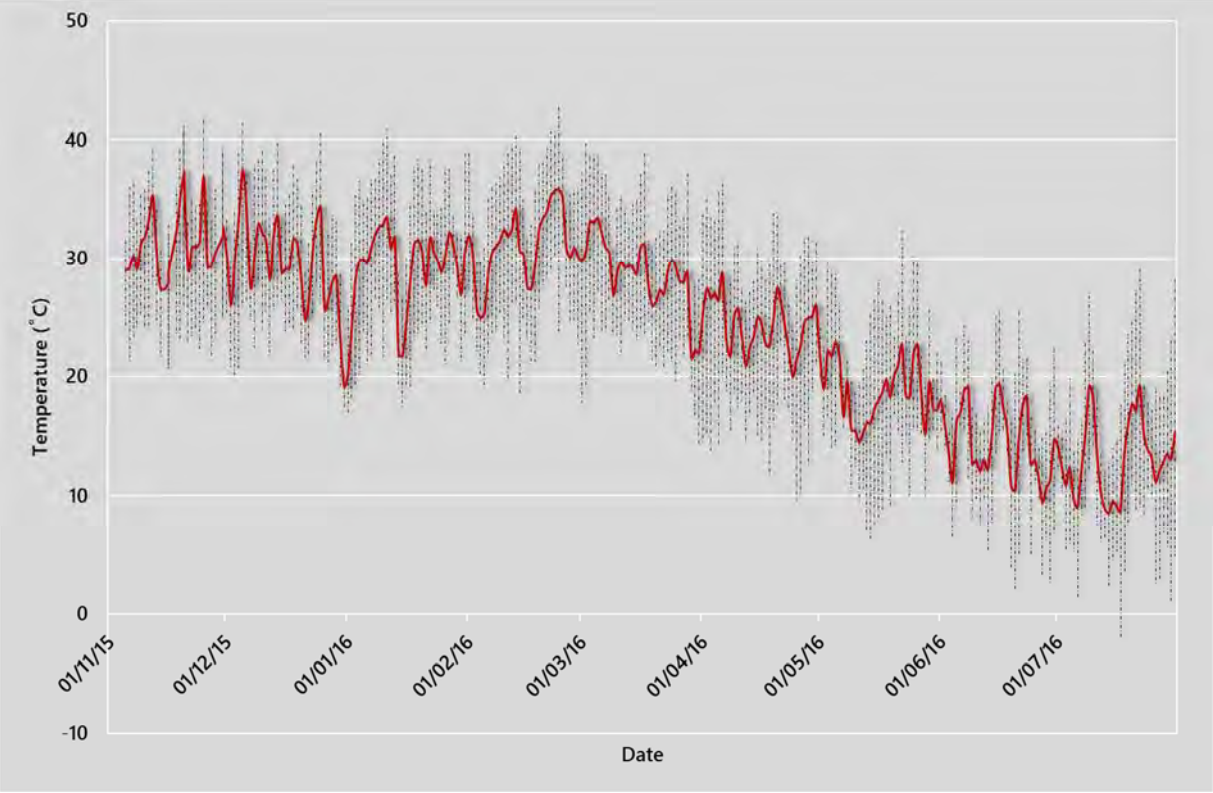


Figure 14-1 Daily average air temperature (red) and observed range in temperature (grey) - Chandler - 5 November 2015 to 31 July 2016

The highest humidity is during winter where it can reach 64% (June) with the lowest humidity at 30% (October to December).

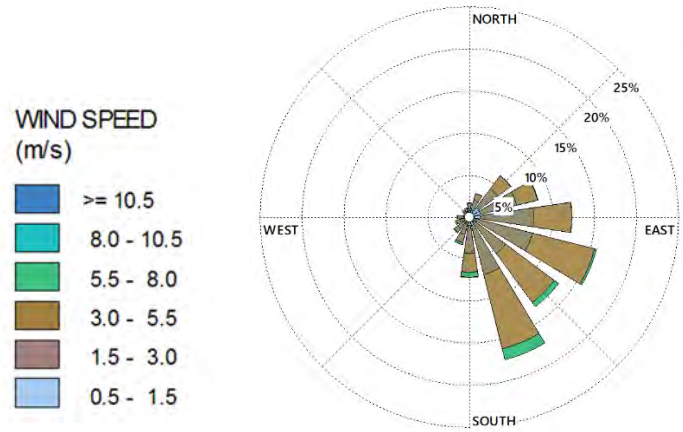
Wind

Annual and seasonal wind roses for the proposed development footprint and vicinity are presented in Figure 14-2. The distribution of wind speed in a number of categories, including calm winds are presented in Figure 14-3.

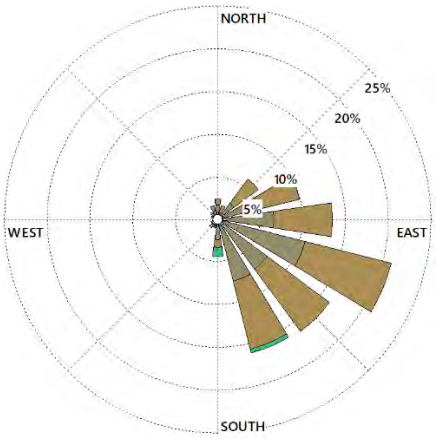
The wind roses indicate that over the course of a year, winds are predominantly from east north-east to south south-easterly directions. The majority of wind speeds experienced within the proposed development footprint are generally in the range 1.5 metres per second to 5.5 metres per second (frequency of 80.8% combined) with the highest wind speeds (greater than 10.5 metres per second) occurring from an east north-easterly direction. Winds of this speed are rare and occur for less than 0.1% of the observed hours during the year (less than eight hours per year). Calm winds (less than 0.5 metres per second) occur during 2.4% of the observed hours during the year.

The seasonal wind roses show a seasonality in wind speeds and direction:

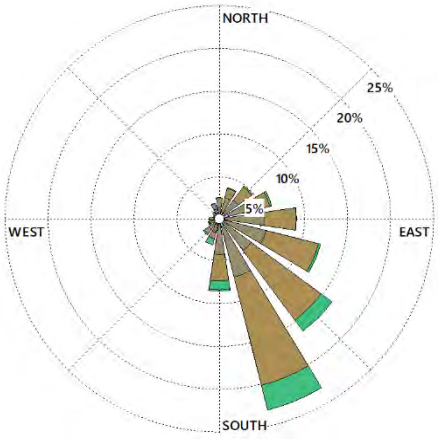
- **Spring**. Winds are predominantly from the north-east to southerly directions with some observed winds originating from a northerly direction. Wind speeds are mainly in the range 3.0 metres per second to 5.5 metres per second (frequency of 46.9%) and 1.5 metres per second to 3.0 metres per second (frequency of 42.3%) categories. High wind speeds (8.0 metres per second to greater than 10.5 metres per second) have not been recorded within the proposed development footprint or vicinity, to date. Calm winds are experienced for 1.1% of the observed hours during the spring months.
- **Summer**. Winds are predominantly from the south south-east direction. Wind speeds during the summer months are predominantly in the range of 1.5 metres per second to 5.5 metres per second (frequency of 79.8%). Calm winds are experienced for 1.1% of the time during the summer months.
- **Autumn**. Winds are predominantly from the south to north-east directions. Wind speeds are predominantly in the 1.5 metres per second to 5.5 metres per second categories (frequency of 82.8%). Calm winds are experienced for 2.8% of the time during autumn months.
- **Winter**. Winds are predominantly from the east south-east direction. Wind speeds during the winter months are predominantly in the range of 1.5 metres per second to 5.5 metres per second (frequency of 75.3 %). Lighter winds (1.5 metres per second to 3.0 metres per second) are experienced for 46.1% of the observed hours during the winter months. Calm winds are experienced for 4.1% of the time during winter months.



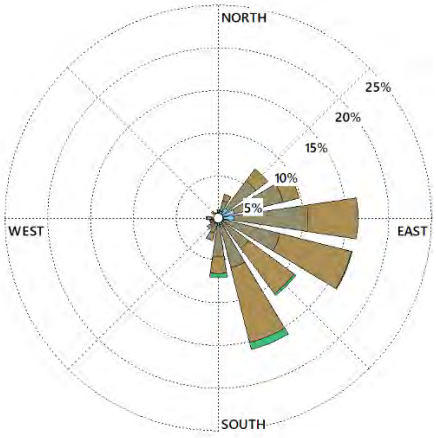
Annual - calms 2.4% [Partial]



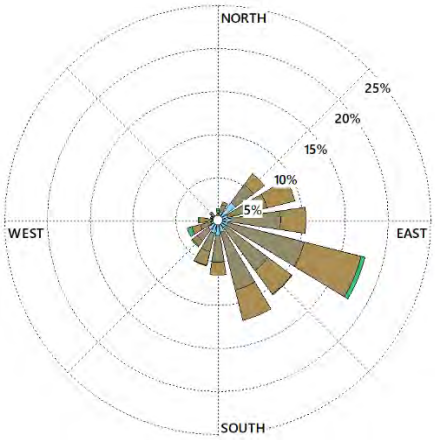
Spring - calms 1.1% [Partial]



Summer - calms 1.1%



Autumn - calms 2.8%



Winter - calms 4.1% [Partial]

Figure 14-2 Annual and seasonal wind roses - Chandler – 5 November 2015 to 31 July 2016

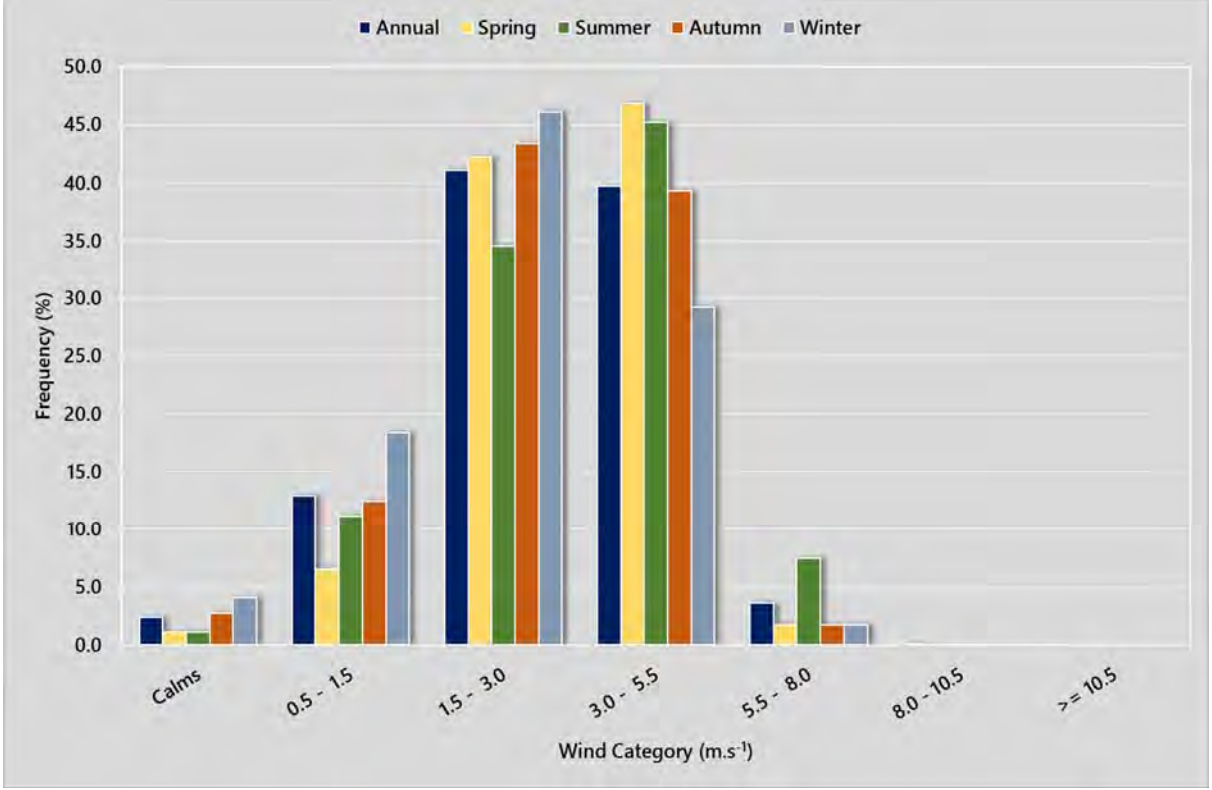


Figure 14-3 Annual and seasonal wind speed distribution - Chandler – 5 November 2015 to 31 July 2016

14.3.2 Vegetation

Vegetation within the proposed development footprint and vicinity is dominated by an understorey of short grasses and low to tall shrublands. The grasses consist of predominately *Aristida* and *Enneapogon* species, but also highly flammable soft and hard spinifex (*Triodia pungens* and *Trioda basedowii*). The shrublands consist primarily of mulga (*Acacia aneura*) or witchetty bush (*Acacia kempeana*) with scattered desert oak (*Allocasuarina decaisneana*). Vegetation is generally sparse and only after significant rainfall events does density become an issue for bushfires.

A detailed description of vegetation within the proposed development footprint and vicinity is provided in Chapter 7 and Appendix O.

14.3.3 Bushfire history

Mapping obtained from North Australia and Rangelands Information shows areas of fire scarring within the proposed development footprint and vicinity in 2011. The fire history of the proposed development footprint and vicinity is shown in Figure 14-4. Evidence of that fire and previous bushfires in the vicinity of the proposed development footprint are shown in Plate 14-1 and Plate 14-2. The fire had a significant adverse impact on the open mulga community in this area. Most of

the affected vegetation were mature species. Since then, little to no re-growth of that particular community has occurred in this area.

Desert oaks in the mine infrastructure area also show evidence of fire, but not at the proposed accommodation village. There is also no evidence of fire within the vicinity of the proposed Apirnta Facility. The majority of understorey plants, or those that depend on fire to regenerate, have regrown and now flourish since the bushfire in 2011. Note, the plant communities shown in Plate 14-1 lie outside of the proposed mine infrastructure area.



Plate 14-1 Evidence of past bushfire and regrowth of juvenile mulga in the foreground



Plate 14-2 Shrubs in the background scared by bushfire and understorey regrowth in the foreground

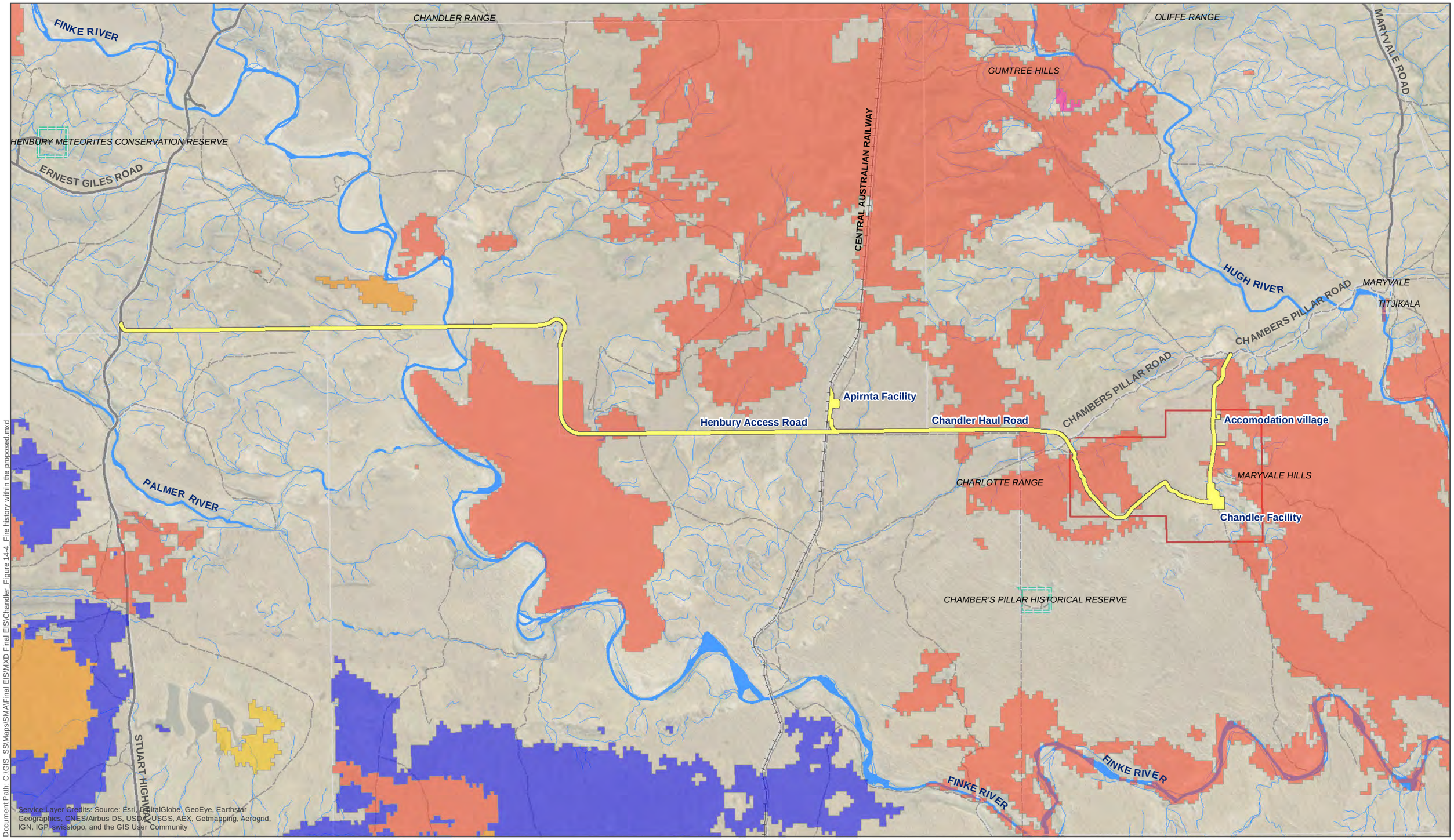
14.3.4 Fire protection zones

Certain areas have been declared fire protection zones in the NT. These fire protection zones are:

- All of the Vernon Region (essentially the greater Darwin and Batchelor/Coomalie areas).
- A 50 kilometre radius from Katherine Post Office.
- A 50 kilometre radius from Tennant Creek Post Office.
- A 50 kilometre radius from Alice Springs Airport.

Fires cannot be lit in these areas without a permit at any time of the year (DENR 2016).

None of the above fire protection zones are located within the proposed development footprint or vicinity.



Document Path: C:\GIS_SS\Maps\SMA\Final EIS\MXD Final EIS\Chandler_Figure 14-4_Fire history within the proposed.mxd

N

4 2 0 4 Kilometers

Coordinate System:
GDA 1994 MGA Zone 53

Legend

- Proposed development footprint
- Watercourse
- ML30612

Years since last burnt

- 3
- 4
- 5
- 7
- 14

Figure 14-4
Fire history within the proposed development footprint and vicinity

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006. Data supplied by Department of Land Resource Management
Data source: DPI & F, Land systems polygons, 1989; Geoscience Australia, 250K Topo base data, 2006; USGS, SRTM elevation, 2000; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller

14.4 Assessment of risk during construction, operation and closure and rehabilitation

There may be an increase in the incidence of bushfire from the accidental ignition of combustible fuels during construction, operation, and closure and rehabilitation of the Proposal. The causes of bushfire may be triggered as a result of:

- Hot works.
- Use/storage of flammable and/or volatile fuels.
- Smoking cigarettes.

Bushfires may also be triggered from natural events (e.g. lightning strike), from back burning on surrounding pastoral properties and from deliberately lit fires outside of the proposed development footprint. If a bushfire were to occur, humans, assets and the environment may be impacted.

The above factors may increase the likelihood of bushfires within or in the vicinity of the proposed development footprint, potentially near highly flammable plant species including soft and hard spinifex (*Triodia pungens* and *Trioda basedowii*) (refer to Plate 14-3).

Baseline wind data indicates that during summer, wind speeds between 3.0 metres per second to 5.5 metres per second occur for 45% of the season and originate from the south south-east. The existing Maryvale Hills would act as a natural buffer to any fires spreading from this direction.



Plate 14-3 Spinifex grass within the proposed accommodation village.

14.5 Mitigation and monitoring

Mitigation and management measures proposed to reduce the incidence of bushfire during construction, operation, and closure and rehabilitation of the Proposal are listed in Table 14-2. These measures would be incorporated into the CEMP, OEMP and/or RCP for the Proposal. A draft Bushfire Management Plan has also been prepared for the Proposal (refer to Appendix O).

Table 14-2 Mitigation and management measures (bushfire)

ID	Outcome	Mitigation/management measure	Timing
BF.1	Reduced incidence of bushfire (protection of human life, assets and the environment)	Finalise draft Bushfire Management Plan prior to construction and incorporate into the CEMP, OEMP and RCP. The plan collates measures to mitigate and manage potential impacts on the humans, assets and the environment.	Pre-construction
BF.2	Reduced incidence of bushfire (protection of human life, assets and the environment)	Undertake fuel load assessments annually to assess bushfire potential and need for pro-active controls, e.g. back burning.	Construction, operation, closure and rehabilitation
BF.3	Reduced incidence of bushfire (protection of human life, assets and the environment)	Create fire breaks/asset protection zones with reference to prevailing wind directions, highest wind speeds and vegetation types. Preliminary asset protection zones are provided in Table 14-3.	Construction, operation, closure and rehabilitation
BF.4	Reduced incidence of bushfire (protection of human life, assets and the environment)	Consult with the NT Fire and Rescue Service on issues relating to: • Strategic planning of bushfire with respect to the layout of the Chandler Facility. • Fire safety. • Hazard abatement. • Firefighter training. • Operations support and administration.	Pre-construction, construction and operation
BF.5	Reduced incidence of bushfire (protection of human life, assets and the environment)	Ensure bushfire suppression equipment is available on-site.	Construction, operation, closure and rehabilitation
BF.6	Reduced incidence of bushfire (protection of human life, assets and the environment)	Ensure fuels and other flammable materials are stored appropriately and in accordance with applicable regulations.	Construction, operation, closure and rehabilitation

Table 14-3 Preliminary asset protection zone (setbacks)

Area	Vegetation class	Slope class	Asset protection zone setback
Accommodation village	Spinifex grassland and open woodland	Upslope	20 metres
Chandler Facility	Grasses and shrub land	0 - 5°	30 metres
Chandler Haul Road	Grasses and shrub land	0 - 20°	15 metres
Apirnta Facility	Grasses and shrub land	0 - 5°	30 metres
Henbury Access Road	Varied (grassland/shrubland/open woodland)	0 - 45°	15 metres

14.6 Summary of risk assessment

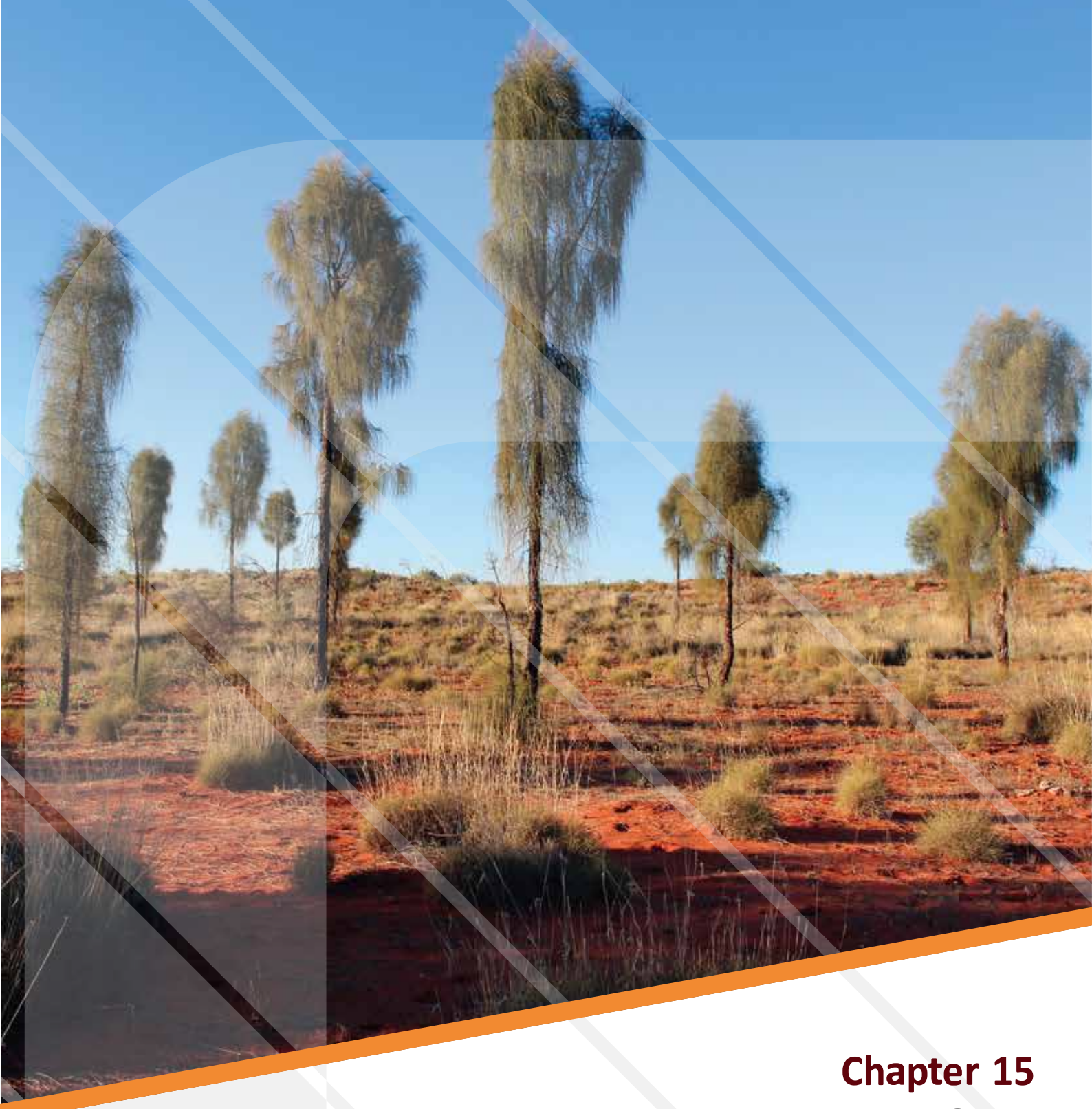
A summary of the risk assessment undertaken for bushfires during construction, operation, and closure and rehabilitation of the Proposal is provided in Table 7-12.

Table 14-4 Summary of risk assessment (bushfire)

Hazard	Pre-mitigated risk			Post-mitigated risks			Risk outcome
	Likelihood	Consequence	Risk ranking	Likelihood	Consequence	Risk ranking	
Natural bushfires occurring	Possible	Major	High	Unlikely	Major	Medium	Risk reduced
Back burning on surrounding pastoral land	Possible	Major	High	Possible	Major	High	Risk same
Hot works resulting in spontaneous ignition	Possible	Major	High	Unlikely	Major	Medium	Risk reduced
Smoking cigarettes	Likely	Major	High	Likely	Major	High	Risk same
Increased ignition sources	Likely	Major	High	Unlikely	Major	Medium	Risk reduced
Flammable and/or volatile fuels	Likely	Major	High	Unlikely	Major	Medium	Risk reduced

14.7 Conclusion

A bushfire hazard analysis was undertaken to assess the potential for an increased incidence of bushfire brought about by the Proposal. While the threat of naturally occurring bushfires and/or human influenced fires is a residual risk, the proposed mitigation and management measures outlined above are considered sufficient to manage the identified risks during construction, operation and closure and rehabilitation of the Proposal.



Chapter 15
Air Quality

This page has been left intentionally blank

15 AIR QUALITY

15.1 Introduction

This chapter provides a review of air quality and human health impacts that may result during construction, operation, and closure and rehabilitation of the Proposal. This chapter draws on a comprehensive air quality risk assessment, which is included as Appendix X. This chapter identifies land sensitivities and describes the existing air quality and meteorology within the vicinity of the Proposal. The potential impacts on air quality and human health are assessed and mitigation and management measures are identified to reduce potential impacts.

The assessment has been prepared in accordance with the Terms of Reference (refer to Appendix A).

15.2 Methodology

The methodology for the air quality risk assessment is presented below, with further detail provided in Appendix X.

15.2.1 Overview

The assessment and evaluation of potential emissions to air was performed using a standard predictive air quality impact assessment methodology, coupled with a risk assessment approach to provide context on the risks associated with various aspects of the study. Combined, the study is referred to as an air quality risk assessment.

The air quality risk assessment was performed to identify and quantify the risks associated with both the construction and the operation of the Proposal (in accordance with the Terms of Reference).

The risk methodology adopted for the construction phase air quality risk assessment and the operational phase air quality risk assessment were similar but not identical, and those methodologies were similar to that used to present the multi-disciplinary assessment presented in Chapter 6. To assist with transparency of interpretation, the methodologies used in the air quality risk assessment are briefly discussed in this methodology section, which also demonstrates how they have been interpreted into the over-arching risk assessment methodology.

The risks assessed in the air quality risk assessment are presented on a dimensionless scale of major significance to neutral significance.

The determined risk may be used to highlight the relative environmental risk and to highlight the general requirement for the application of appropriate controls and mitigation. It is noted that the above approach is designed to provide an overall impact risk, and is not intended to represent the defining determination for the requirement for mitigation and control.

Further details on the methodologies used for quantitative assessment by dispersion modelling and emissions estimation, is presented in Part A, Sections 5.4 and 5.5 of Appendix X.

15.2.2 Assessment context

The air quality risk assessment addresses various air quality impacts that may result during construction and operation of the Proposal. Specifically, the assessment addresses the construction and operation of the proposed Chandler Facility and Apirnta Facility. It also addresses the transfer of materials between the proposed Chandler Facility and Apirnta Facility.

The air quality risk assessment focuses on a number of key air quality issues associated with the construction and operational of the Proposal, including:

- Enabling works, ground clearance, development of construction routes, and other construction activities.
- The operation of the salt mine, including:
    - The mining of salt from a reserve located at approximately 800 metres underground.
    - Dry processing of run of mine salt.
    - Transfer of the product salt to road transport for transfer from the proposed Chandler Facility to the Apirnta Facility where it would be transferred to rail for transfer to the port at Adelaide.
- The operation of a waste storage facility within the salt mine void at approximately 800 metres underground, including:
    - The transfer of containerised waste materials from the rail siding at the proposed Apirnta Facility to the storage facility at the Apirnta Facility.
    - Temporary storage at the proposed Apirnta Facility and transfer to the Chandler Facility by road transport.
    - The emplacement of the containerised waste materials in the excavated salt mine voids at a depth of approximately 800 metres underground.

Due to the extended scope of the air quality risk assessment, covering potential impacts associated with the proposed Chandler Facility, Apirnta Facility, and transport of materials between the two proposed facilities, and the various aspects of the Proposal phasing, the air quality risk assessment has been prepared as a series of parts to make it easier to interpret. The structure of the overall air quality risk assessment report is in five parts, as shown in Figure 15-1 (refer to Appendix X).

Table 15-1 Structure of air quality risk assessment

Part	Study	File reference	Document reference
Part A	Common Study Components (Introduction, description, legislation, existing conditions)	16.1004.FR1A	Section 15.1 and Appendix X
Part B	Chandler Facility (Construction and operation risk assessment)	16.1004.FR1B	Section 15.3, Section 15.6 and Appendix X
Part C	Apirnta Facility (Construction and operation risk assessment)	16.1004.FR1C	Section 15.3, Section 15.6 and Appendix X
Part D	Transport Infrastructure (Construction and operational risk assessment of off-site transport)	16.1004-FR1D	Section 15.3, Section 15.6 and Appendix X
Part E	Management measures and cumulative Impacts (Cumulative impacts of Parts B, C and D)	16.1004.FR1E	Section 15.7, Section 15.6 and Appendix X

15.2.3 Construction phase risk assessment

The construction phase risk assessment used an adapted methodology based upon that published by the United Kingdom *Institute of Air Quality Management* (UK IAQM).

The published methodology adopted to assess the construction phase risks considers the potential risks associated with a range of construction activities including: demolition, earthworks, construction and track-out. For each of those construction activities, a component of each is the risks associated with construction traffic associated with the respective activity.

To reasonably delineate risks of construction traffic from the actual activity, the assessment adapted the UK IAQM methodology by assessing the impact of construction-phase traffic independently of the associated construction activities. The outcome of this adaption was to more reasonably identify the requirement for mitigation.

The methodology assesses the potential magnitude of emissions to air associated with demolition, earthworks, construction track-out and construction vehicles against an assessment of the sensitivity of the location to potential changes in air quality, to assess risk:

$$\textit{Construction risk}_{\textit{(receptors, construction activity)}} = \textit{sensitivity}_{\textit{(receptors)}} \times \textit{magnitude}_{\textit{(construction activity)}}$$

For almost all construction activities, the air quality risk assessment methodology notes that the aim should be to prevent significant effects on receptors through the use of effective mitigation and experience shows that this is normally possible. Given the limited size of the proposed development footprint, no demolition activities, the limited volume of earthworks expected to be involved during construction and the expectation that water would be readily available for dust suppression when required, residual impacts associated with fugitive dust emissions during construction would be anticipated to be 'not significant'.

15.2.4 Operation phase risk assessment

The risks associated with operation emissions to air were assessed by the examination of potential impact magnitude and receptor sensitivity. The risks associated with operation include:

- Mining emissions, including:
    - Controlled discharges, such as mechanical air handling system discharges from the underground mine and fugitive emissions.
    - Uncontrolled discharges, such as wind-blown dust from storage stockpiles.
- Accidental loss of containment, including:
    - Accidental spillages from containerised product salt.
    - Accidental spillages from containment of solid waste materials, such as fly ash or contaminated soil.
    - Accidental spillage from containerised sludge/liquid waste materials, such as spent fuels or contaminated water.

Mining emissions were assessed at the rate of maximum throughput, so that the risks associated with the worst-case conditions during the life of mine could be evaluated.

The potential risks associated with loss of containment requires further considerations in regard to:

- The potential composition of the spilled materials.
- The potential scale (spatial and time) of the spill.

The composition of the potential accidental spill was assumed to be salt (in the case of product salt), or otherwise for waste materials at the maximum permissible concentrations of a wide range of contaminants as prescribed in the *Guidelines for the Siting, Design and Management of Solid Waste Disposal Sites* (NT EPA 2013). This guideline provides specifications for waste composition that may be accepted by the Proposal, and for the purpose of presenting a conservative assessment the maximum concentration of a range of potential contaminants was addressed.

Based upon a unit spill volume, the corresponding impacts as a proportion of their respective air quality standard was assessed. This approach was taken so that the content that would pose the highest level of risk of exceeding its standard has been assessed. For solid waste spills (such as fly ash or other dry wastes), the highest level of risk was determined to be associated with beryllium, and the corresponding component in sludge/liquid wastes (such as chemical processing residues) was determined to be formaldehyde. Correspondingly, beryllium and formaldehyde were used as the composition representing the highest levels of risk of causing an impact exceeding the standard for dry wastes and liquid wastes (respectively) in the air quality risk assessment.

For discrete receptor locations, the operational risk assessment procedure is a function of sensitivity and magnitude:

$$\textbf{\textit{Operational risk}}_{(receptors)} = \textbf{\textit{sensitivity}}_{(receptors)} \times \textbf{\textit{magnitude}}$$

It is also recognised that the proposed development footprint and vicinity is typified by a low density of receptor locations and it is important to evaluate the risks of a range of accidents occurring along the transportation routes and from the proposed Apirnta Facility and Chandler Facility that may result in a loss of containment of waste materials but at locations not impacting fixed receptor locations.

Coupled with this, as the scale of magnitude is also proportional to the assumed loss of containment volume, the assessment was further required to examine the potential risks associated with a range of incident scales. For the air quality risk assessment, the definitions and indicative frequency of industrial incidents was derived from that presented in UK Health and Safety Executive – '*Safety Report Assessment Guide*', and how these definitions were related to the potential volume of accidental loss of containment is presented in Part B, Section 4.5.2 (relating to the Chandler Facility), Part C, Section 4.5.2 (relating to the Apirnta Facility) and Part D, Section 4.2.2 (relating to the transport infrastructure), which are presented as Appendix X. Elements are reproduced in Table 15-2 by way of a summary.

Table 15-2 Definition of accident likelihood (Parts B, C and D)

Likelihood	Definition	Indicative frequency band (per year)	Loss of Containment Volumes (as TEU and FIBC/ IBC Units)		
			Part B and Part C		Part D
			Dry Wastes	Sludge Wastes	Dry/Sludge Wastes
Frequent	Event would occur regularly on the Proposal site	F > 10	< 1 FIBC Incidental spillage	<1 IBC Incidental spillage	not assessed
Likely	Likely to occur a few times in the lifetime of the Proposal	$10 > F > 10^{-1}$	1 FIBC Rupture of FIBC	1 IBC Rupture of IBC	Loss of containment of up to 1 TEU
Occasional	Could occur in Proposal lifetime; root causes likely to have occurred at the Proposal site	$10^{-1} > F > 10^{-3}$	1-17 FIBC Equivalent to up to 1 TEU	1-12 IBC Equivalent to up to 1 TEU	Loss of containment of 3 TEUs, representing a likely to ha
Unlikely	Unlikely; incidents known to have occurred in the industry but would require at least two failures	$10^{-3} > F > 10^{-5}$	18-34 FIBC Equivalent to up to 2 TEU	13-24 IBC Equivalent to up to 2 TEU	Loss of containment of 6 TEUs, representing an incident involving two equire at lea
Remote	Highly unlikely, but may exceptionally occur; would require multiple failures	$10^{-5} > F > 10^{-7}$	35-1,700 FIBC Equivalent to 2-100 TEU	25-1,200 IBC Equivalent to 2-100 TEU	not assessed
Incredible	Extremely unlikely that the event would ever occur	$F < 10^{-7}$	>1,701 FIBC (to site capacity)	>1,201 IBC (to site capacity)	not assessed

In regard to the potential scale of accidental spillage, this was assessed for both beryllium (worst case dry waste) and formaldehyde (worst case sludge waste) from the partial loss of small volume storage vessels to the simultaneous loss of containment of all materials at the relevant facility (Chandler Facility and Apirnta Facility). The descriptors of incidents associated with transport infrastructure were maintained, although the 'scale' of accidents was cropped to reflect the more limited scale of accidents, as compared to the proposed Chandler Facility and Apirnta Facility.

Correspondingly, the risk was assessed as:

Operational risk *(receptors, accident likelihood)* ***= sensitivity*** *(receptors)* ***X impact magnitude*** *(accident likelihood)*

15.3 Existing environment

This section identifies land sensitivities and describes the existing air quality and meteorology within the vicinity of the Proposal.

15.3.1 Surrounding land sensitivity

Population dense locations within the vicinity of the Proposal are presented in Table 15-3 and are shown in Figure 15-1.

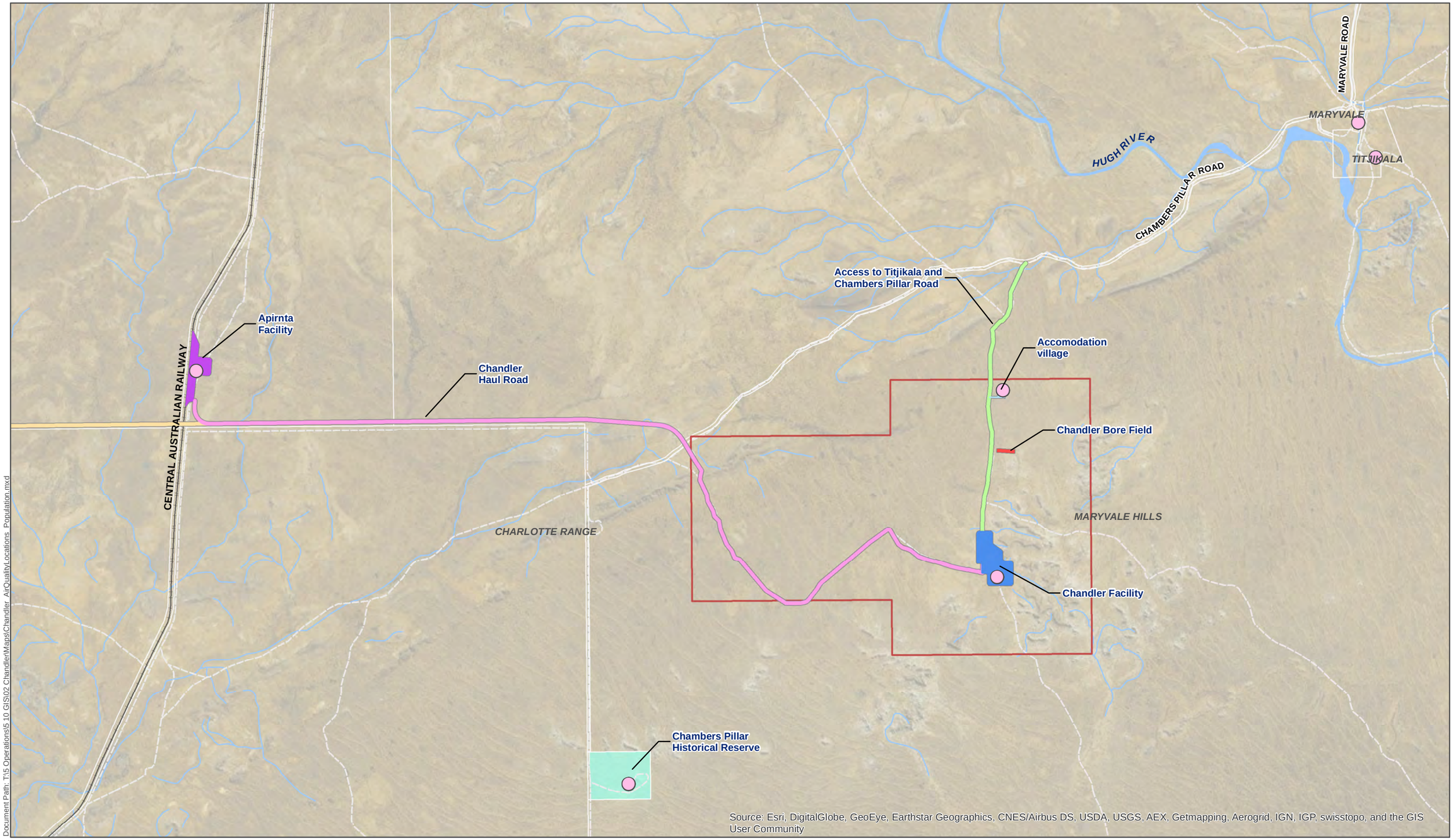
Table 15-3 Population dense locations in the vicinity of the Proposal (ABS 2011)

Rec	Location	Location (km, Australian Map Grid, zone 56)		Distance from proposed Apirnta Facility and Chandler Facility (km)	
		Easting	Northing	Apirnta	Chandler
1	Chambers Pillar Campground	381,119	7,249,134	21	15
2	Titjikala	406,307	7,270,646	44	25
3	Titjikala School	406,186	7,271,014	44	25

The receptor closest to the proposed Chandler Facility is located at Chambers Pillar Campground (Receiver 1), which is located approximately 15 kilometres from the Chandler Facility, and 21 kilometres from the proposed Apirnta Facility. The nearest place of permanent residence is the community of Titjikala (Receiver 2), which is located approximately 25 kilometres from the proposed Chandler Facility and 44 kilometres from the Apirnta Facility.

The discrete receptor locations that were identified as part of the air quality risk assessment are listed in Table 15-4. The table is not intended to represent a definitive list of sensitive land uses, but a cross section of available locations that are used to characterise larger areas, or selected as they represent more sensitive locations which may represent people who are more susceptible to changes in air pollution than the general population[30]. A map showing these locations is provided in Part A, Figure 5 in Appendix X.

[30] *The assessment of construction risks for the proposed Chandler Facility and Apirnta Facility present more accurate distance estimates to site boundaries and site entrances. The distances used above are generalised distances to a location generally representative of the respective site.*



Document Path: T:\5 Operations\5 10 GIS\02 Chandler\Maps\Chandler_AirQualityLocations_Population.mxd

N

2 1 0 2 Kilometers

Coordinate System:
GDA 1994 MGA Zone 53

Legend

- Population dense location
- Railways
- Existing road
- Existing track
- Watercourse
- ML30612
- Henbury Access Road
- Chandler Haul Road
- Access road to Titjikala
- Chandler Facility
- Apirnta Facility
- Accomodation village
- Proposed bore field

Figure 15-1

Population dense locations in the vicinity of the Proposal

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006. Data supplied by Department of Land Resource Management. Copyright Northern Territory of Australia.



Table 15-4 Discrete sensitive receptor locations used in the air quality risk assessment

Receptor	Location	Land Use	Location (km, Australian Map Grid, zone 56)		Approximate distance from (km)	
			Easting	Northing	Apirnta	Chandler
1	Chambers Pillar Campground	Recreation	381,119	7,249,134	21	7
2	Titjikala	Residential	406,307	7,270,646	44	13
3	Titjikala School	Residential	406,186	7,271,014	44	13
4	Titjikala Health Centre	Medical	406,520	7,270,953	44	13
5	Titjikala Residential Property	Residential	406,344	7,270,575	44	13
6	Idracowra	Residential	377,703	7,235,295	32	24
7	Palmer Valley	Residential	321,467	7,261,554	50	68
8	Henbury	Residential	323,051	7,283,404	53	71
9	Orange Creek	Commercial	340,874	7,304,951	54	68
10	Horseshoe Bend	School	424,055	7,211,255	85	55
11	Lilla Creek	Medical	406,755	7,172,781	110	90
12	Desert Oaks Motel	Residential	318,746	7,211,973	77	86
13	Rainbow Valley Cons. Area	Ecological	361,315	7,308,411	50	59
14	Stuarts Well	Residential	343,545	7,307,232	55	68
15	Henbury Meteorite Reserve	Commercial	311,972	7,281,271	63	82
16	Imanpa School	School	255,304	7,218,586	132	147
17	Finke	Residential	457,436	7,170,672	143	113
18	Mac Clark Cons. Res.	Ecological	550,594	7,221,590	207	173
19	Santa Teresa	Residential	436,531	7,331,140	107	88
20	Unknown	Unknown	353,746	7,310,481	54	65
21	Whitehorse Tank	Unknown	349,523	7,298,101	43	56
22	Walkabout Bore	Residential	380,344	7,302,987	46	47
23	Unknown	Residential	385,848	7,301,792	47	45
24	Oak Valley Camping Area	Recreation	391,696	7,302,707	50	45
25	Unknown	Unknown	402,936	7,291,878	50	33
26	Unknown	Unknown	391,157	7,280,672	33	20
27	Unknown	Unknown	370,752	7,273,218	14	20
28	Chandler Facility Accommodation Village	Commercial/ Residential	395,533	7,261,065	30	-
29	Apirnta	Commercial	367,113	7,263,097	-	18

15.3.2 Air quality

The air quality experienced at any location would be a result of emissions generated by natural and anthropogenic sources on a variety of scales (local, regional and global). The relative contributions of sources at each of these scales to the air quality at a location would vary based on a wide number of factors including the type, location, proximity and strength of the emission source(s), the meteorology, land uses and other factors affecting the emission, dispersion and fate of those pollutants.

When assessing the impact of any particular source of emissions on the potential air quality at a location, the impact of all other sources of an individual pollutant must also be assessed. This 'background' air quality would vary depending on the pollutants to be assessed, and can often be characterised by using appropriate air quality monitoring data.

The nearest air quality monitoring performed by the NT EPA to the Proposal is in Darwin, which is located approximately 1,300 kilometres to the north of the Proposal. Given the large distances between the Proposal and the closest air quality monitoring station, caution must be used when using these data.

It is of note that air quality criteria for all monitored pollutants, other than particulates (PM_{10} and $PM_{2.5}$), are achieved within Darwin, and for SO_2, NO_2 and CO concentrations represent between 4 % and 42 % of the relevant criteria.

Although the populations of Alice Springs and Darwin vary significantly (approximately 28,667 and 140,400, respectively) it may be reasonably assumed that combustion/traffic related pollutants such as SO_2, NO_2 and CO would be lower than those measured in Darwin, and the air quality pollutant concentrations at the Proposal site would be lower than those that would be measured in Alice Springs.

Correspondingly, whilst the air quality monitoring data measured in Darwin is acknowledged to be generally unrepresentative of the Proposal site, it should be regarded as being conservative when compared to the conditions expected at the Proposal site.

Air quality in Darwin is measured by the NT EPA at two locations:

- Palmerston air quality monitoring station located at UTM 52L 711,747 m E, 8,616,515 m S.
- Winnellie air quality monitoring station located at UTM 52L 706,817 mE, 8,625,742 mS.

A summary of the air quality data reported by the NT EPA for the period January 1 2015 to December 31 2015 is presented in Table 15-5.

Table 15-5 Assumed background concentrations for the air quality risk assessment

Pollutant	Averaging period	Criterion	Assumed background concentration	
Carbon monoxide (CO)	8 hours	9.0 ppm	1.12 ppm (1.28 $mg \cdot m^{-3}_{(at\ 298K)}$)	The maximum (100th percentile) 8-hour CO concentration measured at Palmerston and Winnellie
Nitrogen dioxide (NO_2)	1 hour	0.12 ppm (120 ppb)	32.85 ppb (61.80 $\mu g \cdot m^{-3}_{(at\ 298K)}$)	The maximum (100th percentile) 1-hour NO_2 concentration measured at Palmerston and Winnellie
	1 year	0.03 ppm (30 ppb)	3.63 ppb (6.83 $\mu g \cdot m^{-3}_{(at\ 298K)}$)	The maximum annual average NO_2 concentration measured at Palmerston and Winnellie
Ozone (O_3)	1 hour	0.1 ppm (100 ppb)	79.74 ppb (156.5 $\mu g \cdot m^{-3}_{(at\ 298K)}$)	The maximum (100th percentile) 1-hour O_3 concentration measured at Palmerston and Winnellie
Sulphur dioxide (SO_2)	1 hour	0.2 ppm (200 ppb)	4.82 ppb (21.62 $\mu g \cdot m^{-3}_{(at\ 298K)}$)	The maximum (100th percentile) 1-hour SO_2 concentration measured at Palmerston and Winnellie
	1 year	0.02 ppm (20 ppb)	0.35 ppb (0.92 $\mu g \cdot m^{-3}_{(at\ 298K)}$)	The maximum annual average SO_2 concentration measured at Palmerston and Winnellie
Particulates (as PM_{10})	1 day	50 $\mu g \cdot m^{-3}$	28.09 $\mu g \cdot m^{-3}$	The 75th percentile 24-hour PM_{10} concentration measured at Palmerston and Winnellie
	1 year	25 $\mu g \cdot m^{-3}$	22.25 $\mu g \cdot m^{-3}$	The maximum annual average PM_{10} concentration measured at Palmerston and Winnellie
Particulates (as $PM_{2.5}$)	1 day	25 $\mu g \cdot m^{-3}$	12.22 $\mu g \cdot m^{-3}$	The 75th percentile 24-hour PM_{10} concentration measured at Palmerston and Winnellie
	1 year	8 $\mu g \cdot m^{-3}$	8.55 $\mu g \cdot m^{-3}$	The maximum annual average $PM_{2.5}$ concentration measured at Palmerston and Winnellie
Lead (Pb)	1 year	0.5 $\mu g \cdot m^{-3}$	Nd	Nd

Given the isolation of the Proposal and the fact there is not air quality data recorded in Alice Springs, the measured air quality data by the NT EPA in Darwin has been used to represent the baseline conditions at the Proposal site. These assumed baseline concentrations are added to the predicted impact concentrations to determine the cumulative impact:

$$C_{it} = BG_{it} + PC_{it}$$

Where:

C_{it} = total predicted concentration value for pollutant i over time period t

BG_{it} = assumed background concentration of pollutant i over time period t

PC_{it} = predicted process concentration of pollutant i over time period t

For the purposes of the air quality impact assessment, the background concentration values presented in Table 15-5 have been used. For particulate matter, due to the high variability of short-term concentrations (1- hour averages), the use of the maximum measured values would cause undue distortion of the assumed background and corresponding total predicted concentration. For

short-term particulate matter risks, the 75th percentile of measured 24-hour concentrations was adopted, in lieu of more representative data.

Based upon the data accessed from the NT EPA (and summarised in Table 14 of Part A in Appendix X), compliance with the relevant criteria is noted in Table 15-6.

Table 15-6 shows that air quality measured in Darwin by the NT EPA in 2015 is compliant with the relevant criteria, with the exception for PM_{10} and $PM_{2.5}$. Measured concentrations of CO, NO_2 and SO_2 are significantly below the relevant criterion value. Additional air quality baseline information is presented in Part A, Section 4.3, in Appendix X.

Table 15-6 Darwin air quality compliance with NEMP criteria (2015)

Pollutant	Averaging period	Criterion(1)	Measured value	NEPM Compliance
Carbon monoxide (CO)	8 hours	9.0 ppm	1.1 ppm, measured at Palmerston	✓
Nitrogen dioxide (NO_2)	1 hour	0.12 ppm	0.03 ppm (33 ppb), measured at Palmerston	✓
	1 year	0.03 ppm	0.004 ppm (3.6 ppb) measured at Palmerston	✓
Ozone (O_3)	1 hour	0.1 ppm	0.079 ppm (79 ppb) measured at Palmerston	✓
Sulphur dioxide (SO_2)	1 hour	0.2 ppm	0.005 ppm (4.8 ppb) measured at Palmerston	✓
	1 day	0.08 ppm	nd	✓
	1 year	0.02 ppm	0.0004 ppm (0.35 ppb) measured at Palmerston	✓
Particulates (as PM_{10})	1 day	50 µg·m^{-3}	107.67 µg·m^{-3} measured at Winnellie	×
	1 year	25 µg·m^{-3}	22.25 µg·m^{-3} measured at Winnellie	✓
Particulates (as $PM_{2.5}$)	1 day	25 µg·m^{-3}	77.86 µg·m^{-3} measured at Winnellie	×
	1 year	8 µg·m^{-3}	8.6 µg·m^{-3} measured at Winnellie	×
Lead (Pb)	1 year	0.5 µg·m^{-3}	nd	nd

Notes (1) units presented as parts per million (ppm) or micrograms per cubic metre of air (µg·m^{-3})

15.3.3 Meteorology

The meteorological conditions surrounding the Proposal have been characterised using data collected by:

- The proponent, at a privately-owned meteorological monitoring station located at the site of the proposed Chandler Facility.
- The Australian Government Bureau of Meteorology (BoM) at Alice Springs Airport.

A summary of the relevant monitoring sites and the parameters measured at both monitoring sites is provided in Table 15-7.



Table 15-7 Details of the meteorological monitoring surrounding the Proposal

Site name	Relative location	Approximate location (E)	Approximate location (S)	Parameters measured	Site commissioned
Tellus Chandler Facility	On-site at Chandler Facility Zone 53J	392,510	7,258,500	Wind speed Wind direction Relative humidity Air temperature	Nov 2015
BoM Alice Springs Airport **Station #015590**	Alice Springs Zone 53K	386,800	7,367,940	Evaporation Wind speed Wind direction Sunshine radiation Rainfall Air temperature Mean sea level pressure Soil temperature Total cloud amount Upper air wind speed	1941 air wind

In order to determine a representative meteorological year for use in dispersion modelling, consecutive five years of meteorological data (2011-2015) from Alice Spring Airport were analysed against the long term meteorological conditions. Specifically, the following parameters were analysed:

- Percentage of calm wind speed events (wind speed <0.5 $m.s^{-1}$)[31].
- Hourly wind speeds observed at 9:00 am and 3:00 pm.
- Hourly temperature at 9:00 am and 3:00 pm.
- Hourly relative humidity at 9:00 am and 3:00 pm.

Based on this analysis, it was concluded that the year 2015 was representative of the last five years of meteorological conditions experienced within the proposed development footprint and, therefore, the 2015 calendar year was adopted for use in the air quality impact assessment.

The observations measured by the proponent at their Automated Weather Station (AWS) are clearly representative of the proposed Chandler Facility as that is the location of the meteorology station, however, its limits are:

- The monitoring period only covers the period from November 2015 to present.
- The compliance status of the station, its operation and maintenance/calibration are unknown.

[31] *Calm wind conditions are conducive to higher concentrations of odour due to poor dispersion of the odour plume.*

The Bureau of Meteorology (BoM) data adequately covers the issues of data quality assurance and monitoring period, however, it is limited by its location compared to the Proposal site. To address these uncertainties, a multi-phased assessment of the meteorology data was performed.

In absence of sufficient on-site meteorological data, site representative meteorological data for the Proposal was generated using a combination of The Air Pollution Model (TAPM) and AERMET meteorological models in a format suitable for subsequent use in the AERMOD dispersion model. TAPM, developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) is a prognostic model which may be used to predict three-dimensional meteorological data and air pollution concentrations.

TAPM predicts wind speed and direction, temperature, pressure, water vapour, cloud, rain water and turbulence. The program allows the user to generate synthetic observations by referencing databases (covering terrain, vegetation and soil type, sea surface temperature and synoptic scale meteorological analyses) which are subsequently used in the model input to generate site-specific hourly meteorological observations at user-defined levels within the atmosphere.

TAPM is known to predict less calm wind conditions than is usually recorded in the data from a monitoring station. TAPM may assimilate actual local wind observations to optimise the model solution. In this case, no data were assimilated into the TAPM model run.

Part A, Sections 4.4 and 4.5 and Part A, Appendix A-1 presented in Appendix X provide a detailed summary of the prevailing meteorology, and describe how the data was used in the air quality risk assessment. The summary of the meteorology representative of the Chandler Facility is presented in Part B, Appendix B-1, and that for the Apirnta Facility is presented in Part C, Appendix C-1.

15.4 Assessment of risks during construction

This section presents the potential impacts (both direct and indirect) on air quality during construction of the Proposal. Mitigation measures to avoid or reduce these impacts are discussed in Section 15.7.

In the air quality risk assessment, the sensitivity of the receiving environment was evaluated against the potential construction dust emission magnitude of emissions from each construction activity to categorise the pre-mitigated ('preliminary') risk, and to identify the key required mitigation measures.

In regard to the residential properties located within 50 metres of the Stuart Highway as it passes through Alice Springs, those locations were considered to have a 'high' sensitivity to changes in air quality that might be resultant from construction phase traffic movements. Based upon the number of construction traffic movements, the dust emission magnitude associated with that traffic was assessed as being 'medium', and the resultant preliminary (pre-mitigated) risk was assessed as being 'medium' for both dust soiling impacts and human health effects.

This pre-mitigation risk profile is common to the construction of both the proposed Chandler Facility and the Apirnta Facility and was used to identify the mitigation options necessary to adequately control construction-phase air quality impacts.

15.5 Assessment of risks during operation

15.5.1 Risks associated with emissions from mining

In regard to the pre-mitigated risks associated with mining activities at the proposed Chandler Facility, the predicted ground level concentrations of particulates from mining and combustion gases from local power generation (diesel generators) were assessed against the relevant air quality standards. Using the risk assessment protocol, the marginal impacts were assessed as an impact magnitude and compared to the sensitivity to air quality impacts at a range of receptor locations to derive a risk, which is summarised in Table 15-8.

Table 15-8 Pre-mitigated operational phase risk criteria

TSP	Dust Dep	PM_{10}		$PM_{2.5}$		NO_2		CO
Ann Ave	Ann Ave	Ann Ave	Max 24hr Ave	Ann Ave	Max 24hr Ave	Ann Ave	Max 1hr Ave	Max 8hr Ave
Neutral	Intermediate	Neutral	Intermediate	Neutral	Intermediate /minor	Neutral	Major/ intermediate	Neutral

15.5.2 Risks associated with emissions from loss of containment of product salt

The risks associated with the potential accidental loss of containment of product salt was determined to be negligible.

15.5.3 Risks associated with emissions from loss of containment of waste materials

The risks associated with the potential accidentals of containment of solid waste materials (as beryllium) and sludge/liquid waste materials (as formaldehyde) from the proposed Chandler Facility, Apirnta Facility and spillages during transportation are presented in Part B, Part C and Part D of the air quality risk assessment, respectively (refer to Appendix X).

Table 15-9 provides a succinct summary of the determined 'worst case' pre-mitigated risks associated with the accidental loss of containment of solid wastes (as beryllium) and sludge / liquid wastes (as formaldehyde) at the Chandler Facility and the Apirnta Facility across a range of accidental emission scenarios defined by their respective frequency estimates, based upon industrial accident statistics.

Table 15-9 Worst case pre-mitigated risks

Facility	Loss of containment	Frequent	Likely	Occasional	Unlikely	Remote	Incredible
		<1 FIBC/IBC	1 FIBC/IBC	≤1 TEU	2 TEU	≤100 TEU	≤ capacity
Chandler Facility (Part B)	Solid waste (beryllium)	Neutral	Neutral	Neutral	Neutral	Major / intermed.	Major
	Liquid waste (formaldehyde)	Neutral	Neutral	Intermed. / minor	Intermed.	Major	Major
Apirnta Facility (Part C)	Solid waste (beryllium)	Neutral	Neutral	Neutral	Neutral	Intermed.	Major
	Liquid waste (formaldehyde)	Neutral	Neutral	Neutral	Intermed./ minor	Major	Major

The loss of containment from transportation infrastructure is presented in Part D of the air quality risk assessment and follows a slightly different scale, as it is essentially limited by the tare capacity of the road vehicles. To assess that potential scale of loss of containment, the following were assumed:

- Loss of containment of one container (i.e. a container spillage on the roadway) (one TEU).
- Loss of containment of one truckload (i.e. a collision of one truck and the loss of the entire load) (three TEU).
- Loss of containment of two truckloads (i.e. the collision of two trucks and the loss of both loads) (six TEU).

The results of the risk assessment for the above scenarios are presented in Table 15-10.

Table 15-10 Transport infrastructure and potential loss of containment risks

Facility	Loss of Containment	Likely	Occasional	Unlikely
		≤1 TEU	3 TEU	6 TEU
Transport Infrastructure (Part D)	Product salt (PM_{10})	Intermediate/ minor	Intermediate	Major/ intermediate
	Solid waste (beryllium)	Major/ intermediate	Major/ intermediate	Major/ intermediate
	Liquid waste (formaldehyde)	Neutral	Neutral	Intermediate/ minor

The determined risk profiles associated with loss of containment at the proposed Chandler Facility and Apirnta Facility are less than that determined by smaller scale losses during transport due to the possible accidental spills from transport occurring in close proximity to receptor locations.

15.6 Assessment of risks during closure and rehabilitation

The air quality risk assessment did not assess risks to air quality and human health during closure and rehabilitation of the Proposal. It is anticipated that the risks would be similar to those presented for construction.

15.7 Mitigation and monitoring

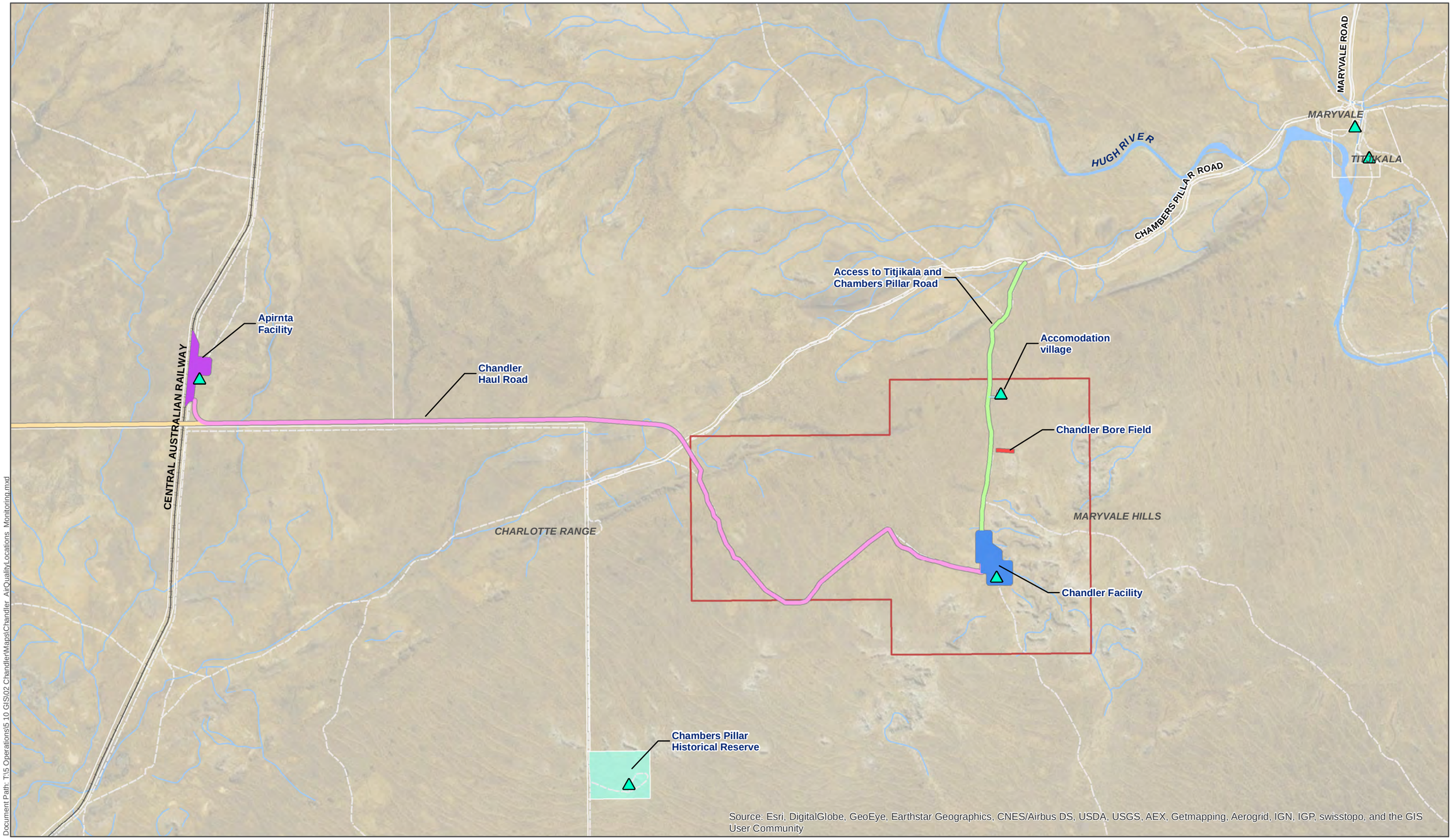
Mitigation and management measures proposed to minimise the potential impacts on air quality and human health during construction, operation, and closure and rehabilitation of the Proposal are

listed in Table 15-11. These measures would be incorporated into the CEMP, OEMP and/or RCP for the Proposal.

Table 15-11 Mitigation and management measures (air quality)

ID	Outcome	Mitigation/management measure	Timing
AQ.1	Minimisation of air quality and human health impacts	Prepare an Air Quality Management Plan.	Pre-construction
AQ.2	Minimisation of dust and associated human health risks	Ensure effective communication between potentially affected communities and the proponent.	Construction
AQ.3	Minimisation of dust and associated human health risks	Perform daily on-site and off-site inspections.	Construction
AQ.4	Minimisation of dust and associated human health risks	Promote a program of considerate vehicle operation and sustainable travel.	Construction
AQ.5	Minimisation of dust and associated human health risks	Use enclosed tankers for the transportation of bulk materials.	Construction
AQ.6	Minimisation of dust and associated human health risks	Implement measures to ensure that vehicle track-out is adequately controlled.	Construction
AQ.7	Minimisation of dust and associated human health risks	Establish a dust monitoring network to monitor dust emissions within the development envelope. Dust monitors would likely be installed at: • Chandler Facility • Apirnta Facility • Accommodation village • Community of Titjikala (refer to Figure 15-2).	Construction
AQ.8	Minimisation of particulate emissions from mine surface operations	Ensure use of diesel engines that comply with the emission standards of the United Stated Environmental Protection Agency (Tier 4 Emission Standards).	Operation
AQ.9	Minimisation of particulate emissions from mine surface operations	Install windbreaks at run-of-mine salt stockpiles.	Operation
AQ.10	Minimisation of particulate emissions from mine surface operations	Install windbreaks at sandstone, shale, limestone and topsoil stockpiles. In addition to windbreaks, shape and profile and rehabilitate stockpiles, as necessary.	Operation
AQ.11	Minimisation of dust and associated human health risks	Enforce vehicle speed restrictions, undertake surface improvements or surface treatments (including wet suppression and chemical stabilisation).	Operation
AQ.12	Minimise risk of loss of containment of waste materials	Ensure handling of IBC/FIBC from TEU containers is performed on a strict one-at-a-time basis, to avoid the potential for spillage of contents of multiple containers.	Operation
AQ.13	Minimise risk of loss of containment of waste materials	Ensure containers are removed from trucks in an appropriately bunded area to minimise the surface area of any spills and to enable efficient clean-up of any spilled materials. Ensure liquid waste is managed through a liquid waste collection system designed to	Operation

ID	Outcome	Mitigation/management measure	Timing
		allow for sufficient capacity of liquids to be removed (e.g. 110% of potential spill volume).	
AQ.14	Minimise risk of loss of containment of waste materials (transportation)	Develop a collision avoidance system that provides a visible and audible positive confirmation of the presence of other vehicles travelling along the proposed Chandler Haul Road. Visible and audible alarm would alert drivers when haul trucks are within 500 metres of each other, requiring a reduction in speed.	Operation
AQ.15	Minimise risk of loss of containment of waste materials (transportation)	Restrict loads containing common and/or more toxic waste components, such that: • Less than one TEU equivalent is carried in one movement. • Less than one TEU equivalent is carried in any two sequential movements (to manage out the potential of loss of containment from collisions).	Operation
AQ.16	Minimise risk of loss of containment of waste materials (transportation)	Manage loss of containment at Orange Creek, Desert Oaks Motel, Stuart Wells and at the Apirnta Facility through the implementation of specific mitigation measures, which include: • A pre-prepared management response plan would be prepared for each location. • Restrictive speed limits imposed for road transport as it passes each of the locations. • The content of the response plan would need to be communicated to the respective residents, and also posted prominently for public reference in the unlikely event of a loss of containment at those locations. • The provision of spill kits at each location.	Operation



Document Path: T:\5 Operations\5 10 GIS\02 Chandler\Maps\Chandler_AirQualityLocations_Monitoring.mxd

N

2 1 0 2 Kilometers

Coordinate System:
GDA 1994 MGA Zone 53

Legend

- Air quality monitoring location
- Railways
- Existing road
- Existing track
- Watercourse
- ML30612
- Henbury Access Road
- Chandler Haul Road
- Access road to Titjikala
- Chandler Facility
- Apirnta Facility
- Accomodation village
- Proposed bore field

Figure 15-2
Population air quality monitoring locations

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006. Data supplied by Department of Land Resource Management. Copyright Northern Territory of Australia.

15.8 Assessment of post-mitigated risks

The same risk assessment procedure was re-applied, with consideration of the additional mitigation measures that have been identified by the preliminary (pre-mitigated) risk assessment. These residual risks are presented below.

15.8.1 Post-mitigation construction-phase risks

For almost all construction activity, the adapted methodology notes that the aim should be to prevent significant effects on receptors through the use of effective mitigation and experience shows that this is normally possible. Given the limited size of the Proposal site, no demolition activities, the limited volume of earthworks expected to be involved in the Proposal and the expectation that water would be readily available for dust suppression when required, residual impacts associated with fugitive dust emissions from the Proposal would be anticipated to be not significant.

15.8.2 Post-mitigation operational-phase risks

In regard to the post-mitigated risks associated with mining activities at the proposed Chandler Facility, the significant control is the adoption of US EPA Tier 4 compliant diesel engines, which controls the risk from major/intermediate to neutral (refer to Table 15-12).

Table 15-12 Post mitigation operational phase risks

TSP	Dust Dep	PM_{10}		$PM_{2.5}$		NO_2		CO
Annual Average	Annual Average	Annual Average	Max 24hr Ave	Annual Average	Max 24hr Ave	Annual Average	Max 1hr Average	Max 8hr Average
Neutral	Intermed.	Neutral	Intermed.	Neutral	Intermed./ minor	Neutral	Neutral	Neutral

In terms of particulate matter, quantification of the potential reduction in emissions associated with control measures is not possible. A detailed Air Quality Management Plan would be prepared for the Proposal. It would include measures designed to minimise particulate emissions from the operation of the Proposal.

Although the air quality risk assessment is limited in its ability to model certain management practices upon 'dust' emissions from the mining activities, the Air Quality Management Plan would focus upon the minimisation of dust emissions from mining activities and a program of environmental performance testing would be commissioned to confirm that the assumptions presented in the air quality risk assessment are:

- Reasonably represented.
- Identify where dust emissions may be controlled further.
- Quantify the efficacy of any further controls implemented.

The risks associated with the potential accidentals of containment of solid waste materials (such as beryllium) and sludge/liquid waste materials (such as formaldehyde) from the proposed Chandler Facility, Apirnta Facility and spillages during transportation are presented in Part B, Part C and Part D in Appendix X.

Table 15-13 provides a succinct summary of the determined 'worst case' post-mitigated risks associated with the accidental loss of containment of solid wastes (as beryllium) and sludge / liquid wastes (as formaldehyde) at the proposed Chandler Facility and the Apirnta Facility.

Table 15-13 Worst case post mitigated risks

Facility	Loss of Containment	Frequent	Likely	Occasional	Unlikely	Remote	Incredible
		<1 FIBC/IBC	1 FIBC/IBC	≤1 TEU	2 TEU	≤100 TEU	≤ Capacity
Chandler Facility (Part B)	Solid waste (beryllium)	Neutral	Neutral	Neutral	Neutral	Intermed.	Major/ intermed.
	Liquid waste (formaldehyde)	Neutral	Neutral	Neutral	Intermed./ minor	Major/ intermed.	Major/ intermed.
Apirnta Facility (Part C)	Solid waste (beryllium)	Neutral	Neutral	Neutral	Neutral	Intermed./ minor	Major/ intermed.
	Liquid waste (formaldehyde)	Neutral	Neutral	Neutral	Minor	Major/ intermed.	Major/ intermed.

The loss of containment from transportation infrastructure is presented in Part D of Appendix X and is summarised in Table 15-14. A range of operational constraints have been identified that would be implemented as mitigation controls to restrict the potential impacts of loss of containment from transportation by active limitation of more hazardous components from some truck loads (to reduce the magnitude on impacts from one truckload) and consecutive truck loads (to reduce the magnitude of impacts from two-vehicle collisions).

Further, collision avoidance system, as has been successfully implemented by Yancoal at the Moolarben Coal Operations site would be developed to reduce the potential for vehicle collisions both on-site and off-site.

Table 15-14 Loss of containment risk from transportation infrastructure

Facility	Loss of Containment	Likely	Occasional	Unlikely
		≤1 TEU	3 TEU	6 TEU
Transport Infrastructure (Part D)	Product salt (PM_{10})	Intermediate / minor	Neutral	Neutral
	Solid waste (beryllium)	Major / intermediate	Neutral	Neutral
	Liquid waste (formaldehyde)	Neutral	Neutral	Neutral

15.9 Summary of risk assessment

A summary of the risk assessment undertaken for air quality during construction, operation, and closure and rehabilitation of the Proposal is provided in Table 7-12.



Table 15-15 Summary of risk assessment (air quality)

Hazard	Pre-mitigated risk			Post-mitigated risks			Risk outcome
	Likelihood	Consequence	Risk ranking	Likelihood	Consequence	Risk ranking	
Construction phase impacts (construction traffic in Alice Springs)	Almost certain	Moderate	High	Almost certain	Insignificant	High	Risk reduced
Emissions to air (combustion gases and particulates) from mining activities (NO2 at Chambers Pillar Campsite) (B) (F)	Likely	Major	High	Likely	Minor	Medium	Risk reduced
Loss of containment of 1 TEU of product salt at the Chandler Facility impacting all receptors (C)	Possible	Insignificant	Low	Unlikely	Insignificant	Low	Risk reduced
Loss of containment of 1 TEU of solid waste (as beryllium) at the Chandler Facility affecting all receptors	Possible	Insignificant	Low	Unlikely	Insignificant	Low	Risk reduced
Simultaneous loss of containment of 2 TEU of solid waste (as beryllium) at Chandler Facility	Unlikely	Insignificant	Low	Remote	Insignificant	Low	Risk reduced
Loss of containment of 1 TEU liquid/sludge waste (as formaldehyde) at the Chandler Facility impacting Chambers Pillar Campground	Possible	Minor	Medium	Unlikely	Minor	Low	Risk reduced
Simultaneous loss of containment of 2 TEU liquid/sludge waste (as formaldehyde) at Chandler Facility	Unlikely	Moderate	Medium	Remote	Moderate	Low	Risk reduced
Loss of containment of 1 TEU of product salt at Apirnta Facility	Possible	Insignificant	Low	Unlikely	Insignificant	Low	Risk reduced
Loss of containment of 1 TEU of solid waste (as beryllium) at Apirnta Facility	Possible	Insignificant	Low	Unlikely	Insignificant	Low	Risk reduced
Simultaneous loss of containment of 2 TEU of solid waste (as beryllium) at Apirnta Facility	Unlikely	Insignificant	Low	Remote	Insignificant	Low	Risk reduced
Loss of containment of 1 TEU liquid/sludge waste (as formaldehyde) at Apirnta Facility	Possible	Insignificant	Low	Unlikely	Insignificant	Low	Risk reduced
Loss of containment of 1 TEU of product	Possible	Insignificant	Low	Unlikely	Insignificant	Low	Risk reduced

Hazard	Pre-mitigated risk			Post-mitigated risks			Risk outcome
	Likelihood	Consequence	Risk ranking	Likelihood	Consequence	Risk ranking	
salt at Apirnta Facility							
Loss of containment of 1 TEU of solid waste (as beryllium) at Apirnta Facility	Possible	Insignificant	Low	Unlikely	Insignificant	Low	Risk reduced
Simultaneous loss of containment of 2 TEU of solid waste (as beryllium) at Apirnta Facility	Unlikely	Insignificant	Low	Remote	Insignificant	Low	Risk reduced
Loss of containment of 1 TEU liquid/sludge waste (as formaldehyde) at Apirnta Facility	Possible	Insignificant	Low	Unlikely	Insignificant	Low	Risk reduced
Simultaneous loss of containment of 2 TEU of solid waste (as beryllium) at Apirnta Facility	Unlikely	Insignificant	Low	Remote	Insignificant	Low	Risk reduced

15.10 Conclusion

A risk assessment of potential point and diffuse source impacts of the Proposal on air quality, including ambient air quality (e.g. PM_{10} fraction), dust and odour/gases, has been undertaken for the following activities:

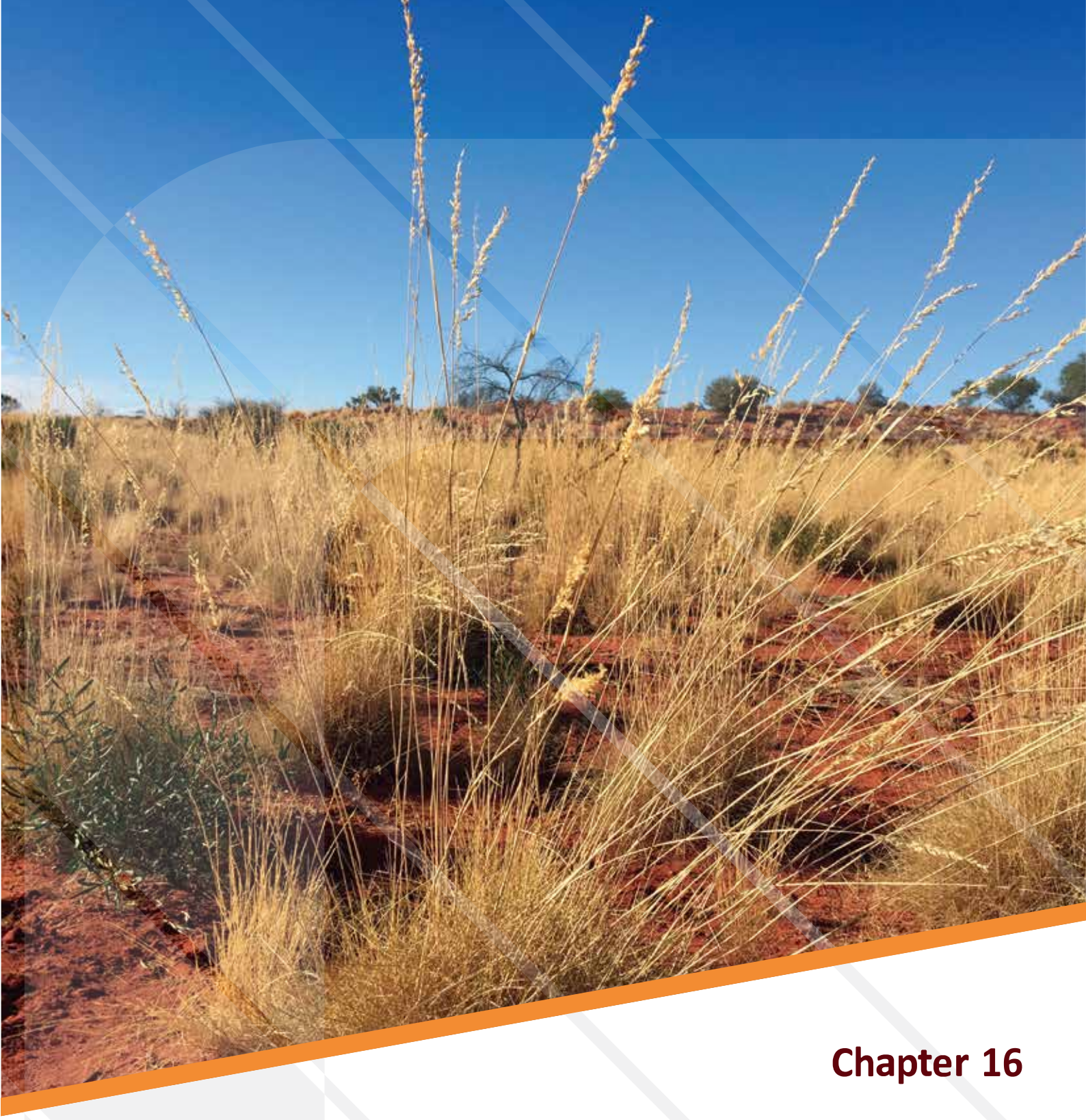
- Power generation.
- Movements of mobile plant and vehicles.
- Wind erosion mobilising dust from exposed surfaces, such as from laydown areas, access tracks and sites of vegetation clearing.
- Storage, processing (e.g. hydraulic backfilling plant) and/or testing of any hazardous waste materials.

The assessment has shown that pre-mitigated construction and operation risks on air quality range from neutral to major. Major risks relate to the transport of solid and liquid waste materials.

Measures for managing and monitoring the impacts of air quality have been considered with respect to the receiving environment and human health. In addition, a construction and operation Air Quality Management Plan would be prepared.

Post-mitigated construction and operation risks on air quality were assessed. With mitigation and management measures in place, risks were reduced. They ranged from neutral to intermediate.

The results of the air quality risk assessment suggest that the Proposal would be acceptable from an air quality and human health perspective.



Chapter 16

Noise and Vibration



This page has been left intentionally blank

16 NOISE AND VIBRATION

16.1 Introduction

This chapter provides a review of potential noise and vibration impacts associated with the Proposal. This includes the consideration of noise and vibration associated with rock blasting during the construction of the proposed decline portal and tunnel and noise generated by mechanical equipment and traffic associated with the construction, operation, and closure and decommissioning of the Proposal. The potential for noise and vibration impacts on surrounding sensitive receptors (defined as residents, hospitals, schools, daycare facilities, elderly housing and convalescent facilities, as well as sites of cultural heritage importance) have been assessed and mitigation and management measures are identified to reduce potential impacts.

The assessment has been prepared in accordance with the Terms of Reference (refer to Appendix A).

16.2 Methodology

Given the distance to the nearest sensitive receptors from the proposed development footprint, a qualitative assessment was undertaken of noise impacts during construction, operation, and closure and rehabilitation of the Proposal. A quantitative assessment of vibration was, however, undertaken for the construction of the proposed decline portal and tunnel given the close proximity of sites of cultural heritage importance (rock structures considered sensitive receptors and demarcated as 'cultural heritage exclusion zones') within the area of the proposed Chandler Facility.

No vibration limits are available for rock structures, therefore, vibration impacts on the cultural heritage exclusion zones were assessed based on the Australian Standard AS2187.2 (2006) *Explosives – Storage and Use – Use of Explosives*. Table J4.4.2.1 of AS2187.2 recommends the limits of vibration for the prevention of cosmetic damage as per British Standard BS7385.2 *Evaluation and Measurement for Vibration in Buildings — Part 2: Guide to Damage Levels from Ground Borne Vibration*. The most conservative cosmetic damage criteria provided by BS7385.2 is for unreinforced or light framed structures which was conservatively adopted for the cultural heritage exclusion zone assessment (refer to Table 16-1). However, note that rock structures would withstand higher levels of vibration without experiencing any cosmetic damage.

Table 16-1 Vibration limits for cosmetic damage (BS7385.2)

Type of building	Peak component particle velocity in frequency range of predominant pulse	
	4 Hz to 15 Hz	15 Hz and above
Un-reinforced or light framed structure. Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

Factors that significantly affect ground vibration from blasting are the:

- Maximum instantaneous charge per delay.
- Distance from the blast to the receiver.
- Geological conditions (which influence vibration propagation).

Blasting is non-linear in nature and variability in ground type and meteorological conditions makes it difficult to accurately predict ground vibration without site-specific measurement data or blast contractor parameters, therefore, conservative predictions have been undertaken. AS2187.2 recommends that ground vibration is estimated using the following equation:

$$V = K_G \left(\frac{R}{Q^{1/2}} \right)^{-B}$$

Where:

V	is the peak vector sum ground vibration peak particle velocity (mm/s)
R	is the distance from charge (metres)
Q	is the maximum instantaneous charge (kilograms)
B, K_G	is the ground constant.

AS2187.2 gives a site constant for a free face in average field conditions of K_G = 1,140 and B = 1.6. This value can vary from 1/5 times to four times depending on geological conditions and other factors. As such, predictions have been undertaken with average and worst case ground condition values.

16.3 Existing environment

This section describes the existing land use, infrastructure, geology, the location of sensitive receptors (including sites of cultural importance), and existing background noise within the proposed development footprint and vicinity (with emphasis on the area of the proposed Chandler Facility).

16.3.1 Existing land use and infrastructure

The proposed Chandler Facility and most of the Chandler Haul Road would be located within Maryvale Station (NT Portion 810), approximately 120 kilometres south of Alice Springs. The proposed Apirnta Facility, Henbury Access Road and a portion of the Chandler Haul Road would be located within Henbury Station (NT Portion 657), to the west of the proposed Chandler Facility (refer to Figure 1-1).

Land within Maryvale Station and Henbury Station is pastoral lease land governed under the NT *Pastoral Land Act.* As such, land within Maryvale Station and Henbury Station is used for pastoral activities (specifically for grazing cattle).

Nearby existing infrastructure includes the Central Australian Railway located approximately 30 kilometres to the west of the Chandler Facility. The proposed Apirnta Facility would be located adjacent to the Central Australian Railway. The Stuart Highway is located approximately 60 kilometres to the west of the proposed Apirnta Facility and 90 kilometres to the west of the proposed Chandler Facility (refer to Figure 1-1).

16.3.2 Geology

The geology within the area of the proposed Chandler Facility consists of a surface formation predominantly of fine silt stone and clay stone above the Langra Formation. The Langra Formation is predominantly course to fine sandstone and sits upon the Jay Creek Limestone Formation to a depth of approximately 560 metres.

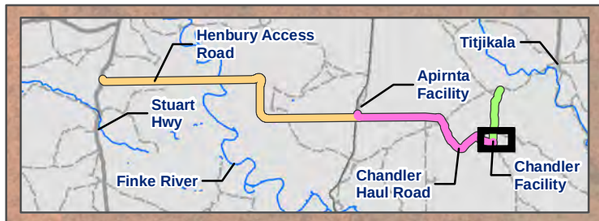
16.3.3 Sensitive receptors and sites of cultural heritage importance

The closest sensitive receptors to the proposed development footprint are located within the community of Titjikala (approximately 25 kilometres to the north-east of the proposed Chandler Facility and 56 kilometres from the proposed Apirnta Facility) (refer to Figure 1-1). Chambers Pillar and the Chambers Pillar Nature Reserve are also located approximately 15 kilometres to the west of the proposed Chandler Facility (refer to Figure 1-1).

Three sites of cultural heritage importance have been identified within the vicinity of the proposed development footprint. These sites consist of rock structures that have been demarcated as 'cultural heritage exclusion zones' and are located in the area of the proposed Chandler Facility (refer to Figure 16-1). At the nearest point, the proposed decline tunnel would be located approximately 200 metres from the northern-most cultural heritage exclusion zone. At this point, the decline tunnel would also be located at depth of approximately 400 metres below the ground surface (refer to Figure 16-1).

16.3.4 Existing background noise

The proposed development footprint is located within a rural area, primarily used for pastoral activities (specifically for grazing cattle). This land use is reflective of the existing background noise environment, with existing noise sources limited to those from cattle and some very light road traffic associated with pastoral activities. Noise is also generated by train movements along the Central Australian Railway and by traffic using the Stuart Highway.



MULGA CREEK

MARYS CREEK

OAK GULLY

HALFWAY CREEK

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Document Path: C:\GIS_SS\Maps\Chandler_Heritage_SMA_AccessTitjikalaShown.mxd

N

250 125 0 250 Meters

Coordinate System:
GDA 1994 MGA Zone 53

Legend

Proposed development footprint

- Access road to Titjikala
- Chandler Haul Road
- Chandler Facility
- Pastoral boundaries
- Cultural heritage exclusion zone
- Watercourse
- Existing track
- Portal and decline

Figure 16-1

Cultural heritage exclusion zones (vibration assessment)

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data source: Geoscience Australia, 250K Topo base data, 2006; AUSURV SURVEYORS, detailed elevation data, 2016.
Created by:adrian.miller

16.4 Assessment of risks during construction, operation and closure and rehabilitation

This section presents the potential noise and vibration impacts during construction, operation and closure and rehabilitation of the Proposal. Mitigation measures to avoid or reduce these impacts are discussed in Section 16.5.

16.4.1 Rock blasting noise and vibration

Rock blasting of the proposed decline portal and tunnel would result in noise and vibration during construction of the Proposal. Due to distance, the noise generated during rock blasting would not be audible at sensitive receptors located within the community of Titjikala (the community of Titjikala is located approximately 25 kilometres to the north-east of the proposed Chandler Facility and 56 kilometres from the proposed Apirnta Facility).

The cultural heritage exclusion zones have been treated as sensitive receptors with regards to ground vibration generated by rock blasting during construction of the proposed decline portal and tunnel. Ground vibration has been predicted for a range of charge masses for varying distances and assuming two cases: average and worst case ground conditions (refer to Figure 16-2 and Figure 16-3). Air-blast overpressure has not been assessed as the excavation would be undertaken at a depth of approximately 400 metres below the ground surface, which shields the pressure wave.

At the nearest point, the decline tunnel would be located approximately 200 metres from the northern-most cultural heritage exclusion zone. At this point, the decline tunnel would also be located at depth of approximately 400 metres below the ground surface (refer to Figure 16-1). As can be seen from the worst case ground vibration predictions, compliance with the most conservative BS7385.2 vibration limits for cosmetic damage is achieved for a charge mass of 100 kilograms. It is expected that much smaller charge masses would be used by the blast contractor (such as five kilograms). If a charge mass in excess of 100 kilograms were required, additional assessment would be undertaken to determine the potential impacts on cultural heritage exclusion zones within the area of the proposed Chandler Facility.

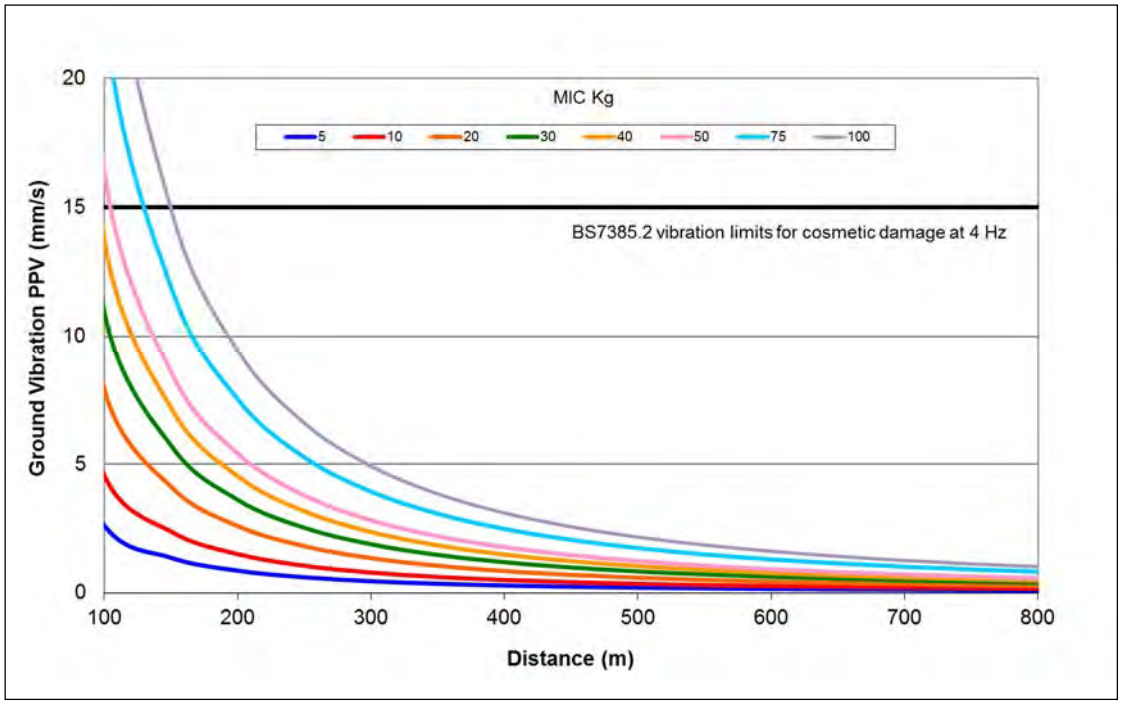


Figure 16-2 Ground vibration predictions for different charge masses and distances (average ground conditions)

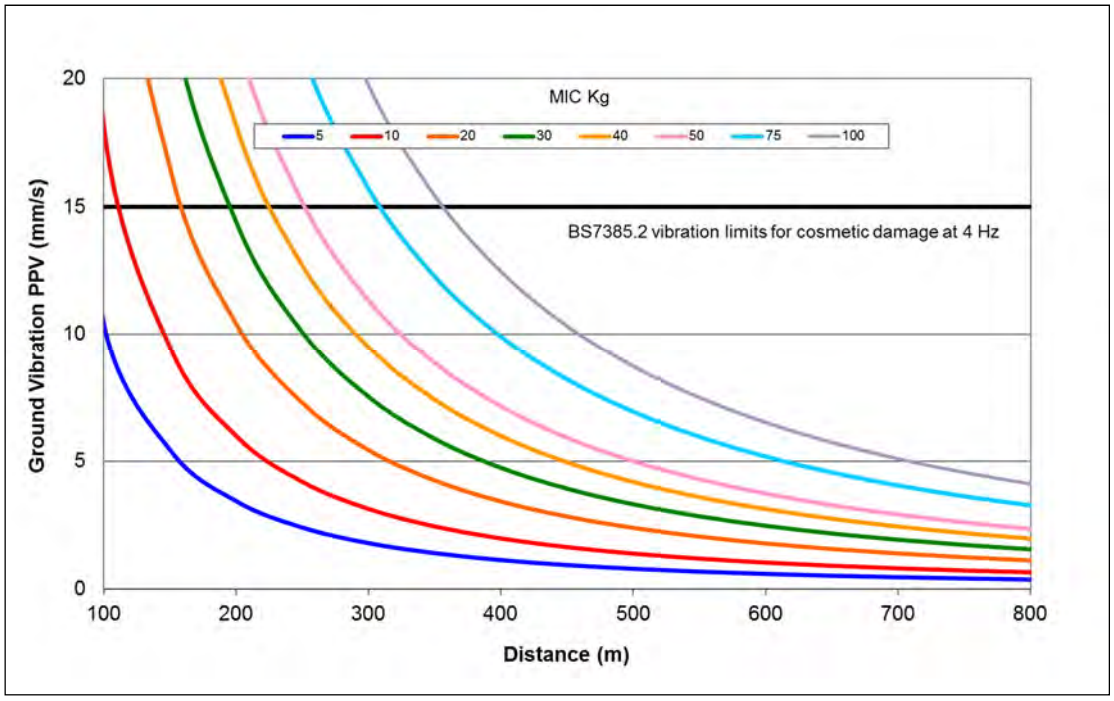


Figure 16-3 Ground vibration predictions for different charge masses and distances (worst case ground conditions)

16.4.2 Mechanical equipment noise

The use of mechanical equipment would result in noise during construction operation, and closure and rehabilitation of the Proposal. Due to distance, the noise generated from mechanical equipment would not be audible at sensitive receptors located within the community of Titjikala.

16.4.3 Traffic noise

Access to the proposed Apirnta Facility would be via the Stuart Highway and the proposed Henbury Access Road. Access to the proposed Chandler Facility would be via the proposed Chandler Haul Road. No residents or communities have been identified along the transportation route (the closest sensitive receptors to the proposed development footprint are located within the community of Titjikala). As such, there would be no impacts to sensitive receptors from transportation noise associated with construction, operation, or closure and rehabilitation of the Proposal.

16.5 Mitigation and monitoring

No mitigation or monitoring measures would be required given that there would be no noise or vibration impacts on sensitive receptors (including sites of cultural heritage importance) in the vicinity of the proposed development footprint during construction, operation, and closure and rehabilitation of the Proposal. Despite this, residents within the community of Titjikala would be informed of the nature of the proposed works undertaken during construction of the Proposal. Contact details to register noise and/or vibration complaints would also be provided to residents within the community of Titjikala.

If a charge mass in excess of 100 kilograms were required for rock blasting of the decline portal and tunnel, additional assessment would be undertaken to determine the potential vibration impacts on cultural heritage exclusion zones within the area of the proposed Chandler Facility.

Mitigation and management measures proposed to minimise noise during construction, operation, and closure and rehabilitation of the Proposal in order to safeguard workers from occupational noise are listed in Table 16-2. These measures would be incorporated into the CEMP, OEMP and/or RCP for the Proposal.

Table 16-2 Mitigation and management measures (noise and vibration)

ID	Outcome	Mitigation/management measure	Timing
NV.1	Workers safeguarded from occupational noise.	Prepare Noise Management Plan (in accordance with the NT *Work Health Safety Act*) prior to construction and incorporate into the CEMP, OEMP and/or RCP for the Proposal.	Pre-construction
NV.2	Workers safeguarded from occupational noise.	Select mobile mechanical equipment to minimise noise emissions and ensure equipment is appropriately maintained to ensure excessive noise is not generated.	Construction, operation, closure and rehabilitation
NV.3	Workers safeguarded from occupational noise.	Check noise emission levels of all critical items of mobile mechanical equipment for compliance with noise limits appropriate to those items prior to the equipment going into regular service.	Construction, operation, closure and rehabilitation
NV.4	Workers safeguarded from occupational noise.	Where practicable, operate mechanical equipment at low speed/power and switch off when not being used rather than leave idling for prolonged periods of time.	Construction, operation, closure and rehabilitation

ID	Outcome	Mitigation/management measure	Timing
NV.4	Workers safeguarded from occupational noise.	Provide appropriate training for operators in order to raise their awareness of potential noise problems and to increase their use of techniques to minimise noise emissions.	Construction, operation, closure and rehabilitation
NV.5	Workers safeguarded from occupational noise.	Where practicable, optimise the layout and positioning of noise-producing equipment and activities on-site to minimise noise emission levels.	Construction, operation, closure and rehabilitation
NV.6	Workers safeguarded from occupational noise.	Ensure workers wear and maintain appropriate PPE.	Construction, operation, closure and rehabilitation
NV.7	Workers safeguarded from occupational noise.	Where noise from a particular activity is identified, measures to mitigate the impact would be investigated, implemented and recorded.	Construction, operation, closure and rehabilitation

16.6 Summary of risk assessment

A summary of the risk assessment undertaken for noise and vibration during construction, operation, and closure and rehabilitation of the Proposal is provided in Table 7-12.

Table 16-3 Summary of risk assessment (noise and vibration)

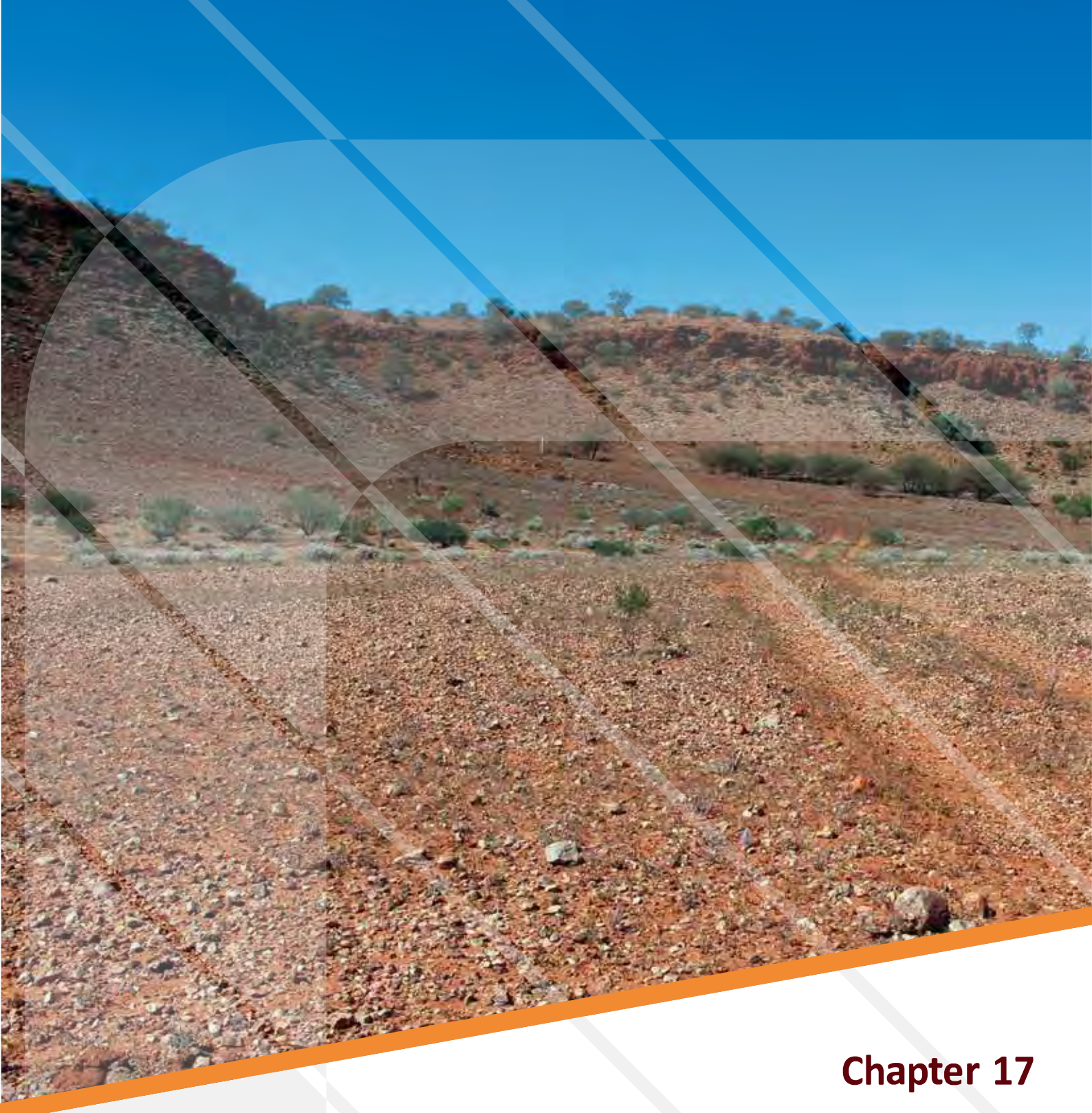
Hazard	Pre-mitigated risk			Post-mitigated risks			Risk outcome
	Likelihood	Consequence	Risk ranking	Likelihood	Consequence	Risk ranking	
Blasting activities result in increased noise levels	Almost certain	Insignificant	High	Likely	Insignificant	Medium	Risk reduced
Blasting activities result in vibration	Almost certain	Major	Extreme	Unlikely	Major	Medium	Risk reduced
Blasting activities result in vibration on known items of cultural heritage significance	Possible	Major	High	Remote	Major	Medium	Risk reduced
Construction and operation noise	Almost certain	Moderate	High	Possible	Minor	Medium	Risk reduced

16.7 Conclusion

The closest sensitive receptors to the proposed development footprint are located within the community of Titjikala (approximately 25 kilometres to the north-east of the proposed Chandler Facility and 56 kilometres from the proposed Apirnta Facility). Due to distance, there would be no noise impacts to sensitive receptors from rock blasting of the proposed decline portal and tunnel, nor would there be noise impacts from the use of mechanical equipment or from traffic during construction, operation, and closure and rehabilitation of the Proposal. There would also be no vibration impacts from rock blasting of the proposed decline portal and tunnel to sites of cultural heritage importance (demarcated as ‘cultural heritage exclusion zones’) within the area of the proposed Chandler Facility.

No mitigation or monitoring measures would be required given that there would be no noise or vibration impacts on sensitive receptors or on sites of cultural heritage importance in the vicinity of the proposed development footprint during construction, operation, and closure and rehabilitation of the Proposal. If, however, a charge mass in excess of 100 kilograms were required for rock blasting of the decline portal and tunnel, additional assessment would be undertaken to determine the potential vibration impacts on cultural heritage exclusion zones within the area of the proposed Chandler Facility.

Mitigation and management measures would be implemented in order to minimise noise during construction, operation, and closure and rehabilitation of the Proposal to safeguard workers from occupational noise. This would include the preparation of a Noise Management Plan that would be prepared in accordance with the NT *Work Health Safety Act.*



Chapter 17
Visual Amenity

This page has been left intentionally blank

17 LANDSCAPE AND VISUAL AMENITY

17.1 Introduction

This chapter provides a review of the visual and landscape values that may be potentially affected by the Proposal. The assessment considers the visibility of the Proposal (specifically, the proposed Chandler Facility and Apirtna Facility). The potential visual impacts on sensitive visual receptors and on the landscape character of the area are assessed. Mitigation measures to reduce potential visual and landscape impacts are provided.

The assessment has been with reference to the *Guidelines for Landscape and Visual Impact Assessment* (IEMA 2013) and in accordance with the Terms of Reference (refer to Appendix A).

17.2 Assessment methodology

The assessment of visual impacts for the Proposal followed the principles set out in *Guidelines for Landscape and Visual Impact Assessment* (IEMA 2013) and involved undertaking the following tasks:

- Reviewing background information.
- Defining the study area by using a zone of theoretical visibility.
- Describing the existing landscape and potentially sensitive visual receptors.
- Undertaking field investigations to confirm desktop assessment and to describe the existing landscape to visually confirm views from the sensitive visual receptors.
- Assessing the potential landscape and visual impacts with a focus on the identified sensitive visual receptors (through a view shed analysis and through field investigations).
- Providing mitigation and management measures to reduce potential landscape and visual impacts.

17.2.1 Review of background information

The desktop assessment involved the interpretation of different land based, publicly available maps, containing information relating to local and regional topography; land uses; soils; biodiversity and cultural heritage. A GIS was used to collate and combine the data. Together, the above process allowed a 'zone of theoretical visibility' to be set and sensitive visual receptors to be identified for ground truthing during field investigations.

17.2.2 The study area

The study area for the visual impact assessment included the following sites (infrastructure) and their surrounding visual catchment:

- Chandler Facility, divided into:
    - Accommodation village.

- Mine infrastructure area.

- Apirnta Facility
- Access and haul roads.

The surrounding visual catchment at each site is described as the zone of theoretical visibility. The zone of theoretical visibility sets an approximate limit for visual receptors that have the potential to be impacted by the Proposal. For the purpose of this assessment, the zone of theoretical visibility was set at a conservative limit using a 25 kilometre radius from the centre of the proposed Chandler Facility and Apirnta Facility. The zone of theoretical visibility for the Proposal is presented in Figure 17-1.

17.2.3 Assessing potential landscape and visual impacts

Landscape impacts were assessed qualitatively based on field investigations. Visual impacts on identified sensitive visual receptors were assessed via a view shed analysis and field investigations.

Field investigations

Field investigations were undertaken over a period of one year to account for seasonal variations at each site. Photographs from each compass direction were taken from potential sensitive visual receptor locations. GPS co-ordinates and field notes were recorded at each strategic location so that future photographs can be taken at the same location to monitor the change that would occur as a result of the Proposal. Field notes included information relating to landscape type, character and individual elements that significantly contribute to uniqueness or visual amenity.

Consultation with Traditional Owners was also undertaken during ecological and cultural heritage field investigations which has contributed to the evidence, knowledge and understanding of key landscape features identified and assessed in the visual impact assessment.

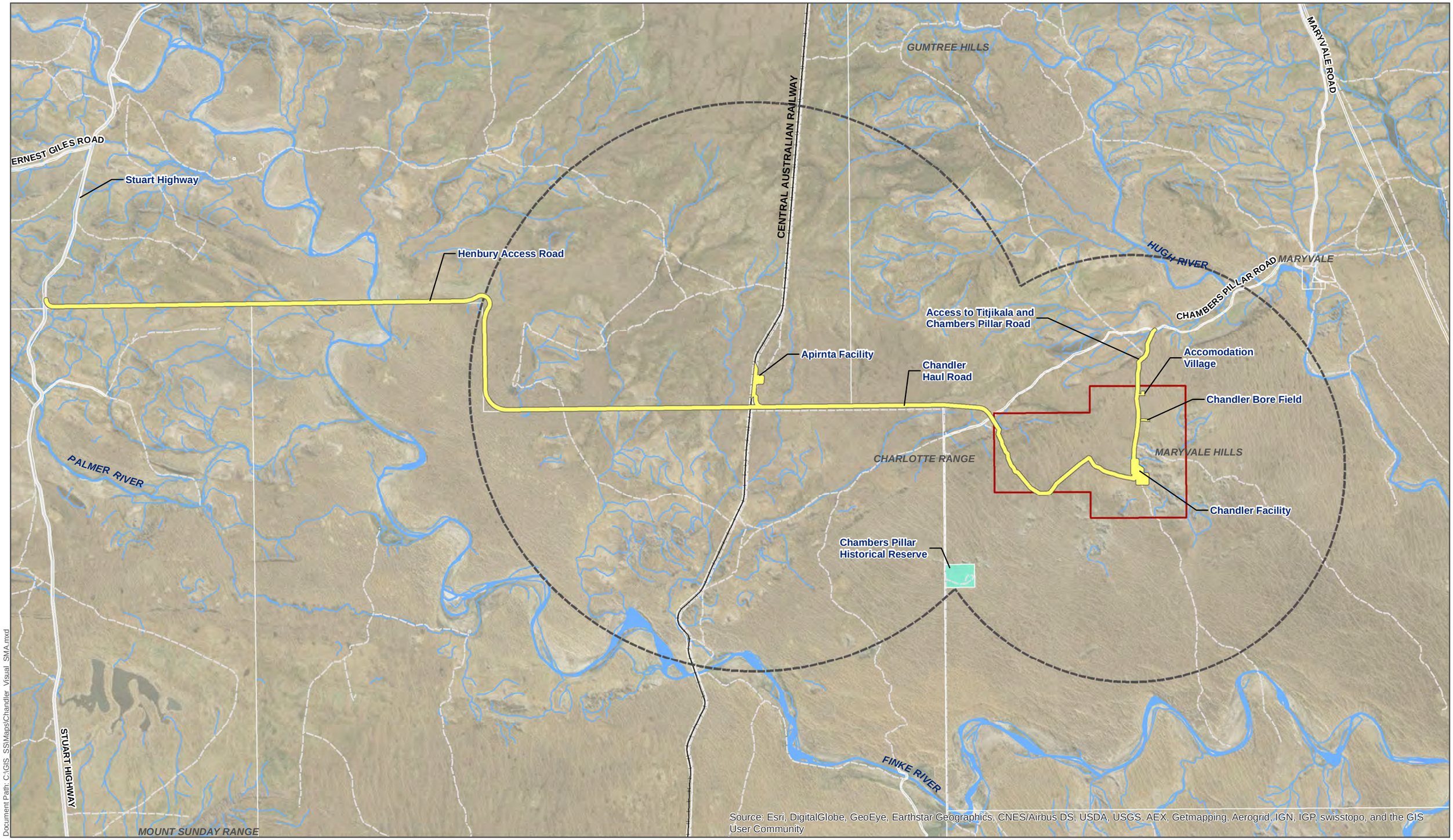
View shed analysis

A view shed identifies terrain (or pixels) visible from an identified location. This tool considers the height of surrounding pixels and the gradual curve of the earth over a large area. The terrain model represents a nominal ground surface and does not portray features such as trees. As such, additional screening by vegetation could further reduce the visibility extent shown in the view shed.

A view shed analysis was prepared to understand the potential visual impacts of aboveground infrastructure at the Apirnta and Chandler Facilities. The objective was to show the proportion of the Proposal or particular features that would be visible from an observer at eye height (1.50 metres to 1.80 metres) for structures that are either 20 metres or 40 metres above the existing ground surface.

Distance of the viewpoint from the Proposal and whether a viewer would be able to see it due to its scale and proximity. Stationary or transient or one of a sequence of views, e.g. from a moving train along the Central Australian Railway (as would be the case for the proposed Aprinta Facility).





Document Path: C:\GIS_SS\Maps\Chandler_Visual_SMA.mxd

N

4 2 0 4 Kilometers

Coordinate System:
GDA 1994 MGA Zone 53

Legend

- Existing road
- Existing track
- Watercourse
- ML30612
- Proposed development footprint
- Zone of theoretical visibility

Figure 17-1
Zone of theoretical visibility for the Proposal

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006. Data supplied by Department of Land Resource Management. Copyright Northern Territory of Australia.

17.3 Existing environment

This section describes the existing landscape at each site within the study area - the accommodation village and mine infrastructure area (Chandler Facility) and the Apirnta Facility. The visual and landscape quality of the proposed development footprint is described and sensitive visual receptors are identified.

17.3.1 Existing landscape

The existing landscape at each site within the study area - the accommodation village and mine infrastructure area (Chandler Facility) and the Apirnta Facility, is described below.

Accommodation village

The proposed accommodation village would be located an area characterised by red sandy loam soil, prostrate grasses dominated by circular clumps of spinifex and sparsely located desert oaks (refer to Plate 17-1). A dune and swale system is the predominant natural landscape feature to the east of the proposed accommodation village.



Plate 17-1 Existing view looking south-west towards the proposed accommodation village

The eastern boundary of the proposed accommodation village is dominated by a vegetated sand dune approximately two to three metres high. The area to the south-west of the proposed accommodation village is dominated by a tall open community of desert oaks.

Views looking south from the proposed accommodation village are dominated by Maryvale Hills (refer to Plate 17-2). Just below Maryvale Hills is the proposed location of the Chandler Facility. The viewing distance is approximately six kilometres from the proposed accommodation village to the proposed Chandler Facility shown in Plate 17-2.



Plate 17-2 Existing view looking south from the proposed accommodation village towards the proposed Chandler Facility– visible on the horizon are Maryvale Hills

Views looking north from the proposed accommodation village are dominated by Charlotte Range (refer to Plate 17-3). Located behind Charlotte Range is Chambers Pillar Road.



Plate 17-3 Existing view looking north-west from the proposed accommodation village – visible in the distance is Charlotte Range

Mine infrastructure area (Chandler Facility)

The proposed mine infrastructure area would be located in an area that is characterised by fine silty and sandy soils and that contains small to medium sized rocks, prostrate grasses and small shrubs (refer to Plate 17-3 to 17-5). The characteristic 'mesa' feature belonging to the Maryvale Hill Geological Formation is shown in Plate 17-5.



Plate 17-4 Existing view looking north across the proposed mine infrastructure area (left) and view looking south-west from the centre of the mine infrastructure area showing mesas (right)



Plate 17-5 Existing view towards the mine portal entry

The existing view from the entrance to the decline portal looking south-west towards Chambers Pillar is shown in Plate 17-6. As shown in Plate 17-6, Chambers Pillar is not visible from the proposed Chandler Facility due to the existing intervening mesas that form Charlotte Range.

Views from Chambers Pillar towards the proposed Chandler Facility and Apirnta Facility are shown in Plate 17-7. Neither the proposed Chandler Facility, nor the Apirnta Facility would be visible from Chambers Pillar due to the existing intervening mesas that form Charlotte Range.



Plate 17-4 Existing view looking south-west from the proposed Chandler Facility towards Chambers Pillar.



Plate 17-5 View east from Chambers Pillar towards the proposed Chandler Facility and Apirnta Facility

Apirnta Facility

The proposed Apirnta Facility would be located in an area that is relatively flat, characterised by sandy soils and prostrate grasses dominated by circular clumps of spinifex (refer to Plate-17-8). The Apirnta Facility would be located beyond the tree line shown in Plate 17-8.

The proposed Apirnta Facility would be positioned up to 500 metres east of the existing Central Australian Railway (refer to Plate 17-8). Access to the proposed Apirnta Facility would be via an existing pastoral lease access track (refer to Plate 17-9)



Plate 17-6 View looking east towards the proposed Apirnta Facility



Plate 17-9 View looking north along the Central Australian Railway - to the east is the site of the proposed Apirnta Facility (left). Access to the site of the proposed Apirnta Facility is via an existing access track (right).

Access and haul roads

Views along the proposed Chandler Haul Road and Henbury Access Road are typically associated with undulating topography, sand dunes and prostrate grasses and low shrubs (Refer to Plate 17-10).



Plate 17-10 View looking east along the proposed Chandler Haul Road. Note the Charlotte Range on the right hand side in the middle of the image.

17.3.2 Visual and landscape quality

The following landscape types characterise the landscape in which the proposed development footprint is located. These include:

- Mesa and range formations.
- Vegetated sand dunes.
- Open grasses and spinifex.
- Flat low lying topography.
- Disturbed grazing land.
- Stock tracks.

The visual quality of these landscape types is summarised in Table 17-1.

Table 17-1 Visual quality assessment of landscape types within the proposed development footprint and vicinity

Landscape type	Visual quality	Description
Mesa and range formations	High	Natural feature of the landscape that is hundreds of millions of years old. Often formed of many contrasting colours that are apparent at different times of the day. Within the vicinity of the proposed development footprint these formations are up to 45 metres high and include the Maryvale Hills and Charlotte Range. Also includes Chambers Pillar located approximately 6.8 kilometres from the proposed Chandler Facility (refer to Plate 17-11).
Vegetated sand dunes	Moderate	A unique landscape feature in the proposed development footprint and vicinity. Dunes are stabilised by prostrate vegetation such as spinifex and native grasses. Sand dunes within the proposed development footprint and vicinity are on average between three to five metres high.
Open grasses and spinifex	Moderate	A traditional landscape feature of the Australian outback (refer to Plate 17-12).
Flat low lying topography	Moderate	A traditional feature of the Australian arid zone. The proposed Chandler Facility and Apirnta Facility are located within predominately flat low lying country with the exception being the surrounding mesa formations noted above.
Disturbed grazing land	Low	The majority of land within the proposed development footprint and vicinity is pastoral (predominantly used for grazing cattle). A lot of the original vegetation on the pastoral land was previously cleared to make way for grazing cattle.
Stock tracks	Low	A feature of the landscape that is a result of historic land use.



Plate 17-8 Example of mesa formations and contrasting colours at Chambers Pillar



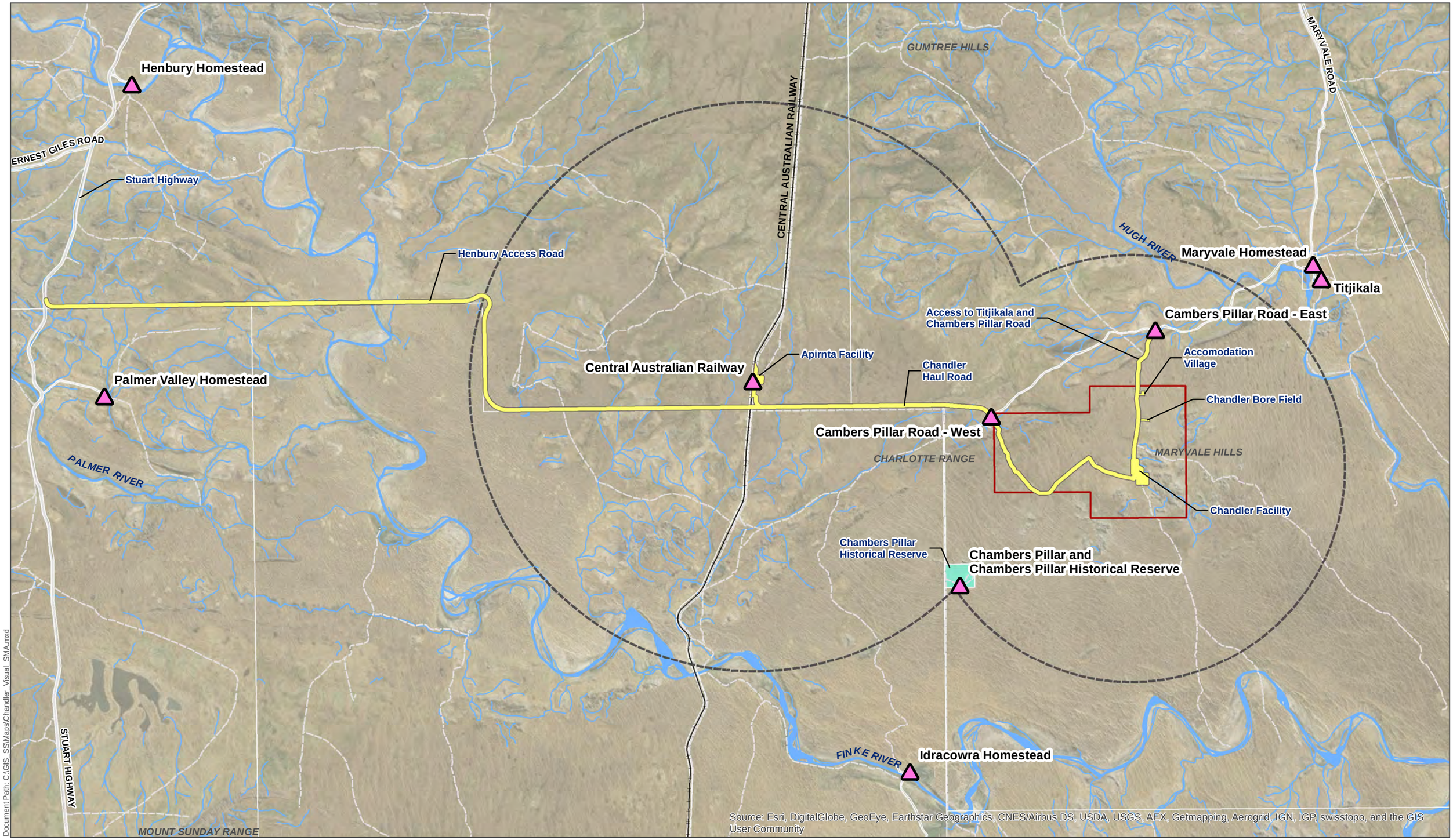
Plate 17-7 Typical clump of spinifex within the proposed development footprint

17.3.3 Sensitive visual receptors

The sensitive visual receptors identified within the zone of theoretical influence were:

- The community of Titjikala.
- Maryvale Homestead.
- Chambers Pillar and Chambers Pillar Historical Reserve.
- Idracowra Homestead.
- Palmer Valley Homestead
- Henbury Homestead.
- Central Australian Railway (in the vicinity of the proposed Apirnta Facility).
- Chambers Pillar Road – East (at the junction of the access road to the proposed accommodation village).
- Chambers Pillar Road – West (at the junction of the proposed Chandler Haul Road).

The location of the sensitive visual receptors is shown in Figure 17-2.



Document Path: C:\GIS_SS\Maps\Chandler_Visual_SMA.mxd

N

4 2 0 4 Kilometers

Coordinate System:
GDA 1994 MGA Zone 53

Legend

- Existing road
- Existing track
- Watercourse
- ML30612
- Proposed development footprint
- Sensitive visual receptor
- Zone of theoretical visibility

Figure 17-2
Sensitive visual receptors

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006. Data supplied by Department of Land Resource Management. Copyright Northern Territory of Australia.

17.4 Assessment of risk during construction

Construction activities would generate visual impacts during the three year construction period. During construction, exposed soils would be visible, along with machinery and equipment required for construction, and the buildings and other infrastructure that would be under construction. The visual impacts would be short-term and limited to the construction period.

It is possible that transient views of construction activities associated with the proposed Apirnta Facility could be seen from within a train travelling north or south along the Central Australian Railway. It is also possible that transient views of construction activities associated with the proposed accommodation village could be seen from vehicles travelling along Chambers Pillar Road. These views would be of a short duration and likely screened by existing vegetation. Therefore, the visual impacts are considered to be minor.

The construction works would not be visible from Maryvale Homestead, the community of Titjikala, Chambers Pillar and Chambers Pillar Historical Reserve, Idracowra Homestead, Palmer Valley Homestead, or Henbury Homestead. This would be due to the distance of the sensitive visual receptors from the proposed construction works and/or due to intervening topography that would block views from the sensitive visual receptors to the proposed construction works (predominately, the Charlotte Range and Maryvale Hills).

17.5 Assessment of risk during operation

This section presents the potential impacts (both direct and indirect) on landscape and visual amenity during operation of the Proposal. Mitigation measures to avoid or reduce these impacts are discussed in Section 17.7.

17.5.1 Direct impacts

The following aboveground infrastructure would be developed as part of the Proposal:

- Accommodation village (Chandler Facility).
- Mine infrastructure area (Chandler Facility), including:
  - Salt processing facilities.
  - Waste unloading area.
  - Waste storage warehouse.
  - Surface hydraulic backfill plant and underground reticulation.
  - Salt and overburden stockpiles.
  - Maintenance buildings.
  - Administration buildings.
  - Solar/diesel hybrid power plant.
  - Clean and raw water dams.
  - Water and sewage treatment.
  - Fuel storage facility.
  - Utility reticulation.
  - A future technology recovery park.

- Apirnta Facility, including:
  - Storage areas for dry and solid waste materials - a steel-framed warehouse and open storage yard.
  - A liquid storage tank to store a variety of liquid wastes.
  - Road and rail interchange areas and a rail siding.
  - A quarantine zone.
  - Internal roads and car parking.
  - Laboratory, office and maintenance and storage shed.
  - Loading bay, weighbridge and vehicle washdown facility.
  - Truck driver amenities.
  - Security gates, fencing, cameras and lighting.
  - Bunding and stormwater drainage.
  - Electricity, water and sewerage services.
- Henbury Access Road and Chandler Haul Road.

A graphical representation of the mine infrastructure area (Chandler Facility) and the Apirnta Facility are provided in Plate 17-9 and Plate 17-14.



Plate 17-9 Graphical representation of proposed above ground infrastructure within the mine infrastructure area (Chandler Facility).

All of the above proposed infrastructure (with the exception of the Henbury Access Road and Chandler Haul Road) would involve the construction of a range of buildings and associated structures, hardstand areas and landscaping.



Plate 17-10 Graphical representation of proposed above ground infrastructure at the Apirnta Facility.

Potential visual amenity impacts would depend on a range of factors including:

- The final locations of above ground infrastructure.
- The height of above ground infrastructure.
- The design and exterior finishes of the buildings and other structures.
- Landscaping and screening provided.
- The extent of clearing required.

The potential landscape and visual amenity impacts of the proposed accommodation village and mine infrastructure area (Chandler Facility), the Apirnta Facility and the Chandler Haul Road and Henbury Access Road are discussed below.

Accommodation village (Chandler Facility)

The siting of the proposed accommodation village took into account topography, soils, vegetation, wind direction and flood risk. The accommodation village would result in a long term change to the landscape in this area, however, with careful design (building finishing and colour), and appropriate landscaping, the landscape would be able to absorb the predicted change.

It is possible that transient views of the proposed accommodation village could be seen from vehicles travelling along Chambers Pillar Road (refer to Sheet 2, Figure 17-3). These views would be of a short duration and likely screened by existing vegetation. Therefore, the visual impacts are considered to be minor. Mitigation and management measures to reduce this potential impact are discussed in Section 17.7.

The proposed accommodation village would not be visible from any of the other identified sensitive visual receptors during operation of the Proposal. This would be due to the distance of the sensitive visual receptors from the proposed accommodation village and due to intervening topography. Henbury Homestead and Palmer Valley Homestead are located over 72 kilometres to the west of the proposed accommodation village (well outside of the zone of theoretical visibility). At these distances, the proposed accommodation village would not be visible. In addition, the proposed accommodation village would not be visible from Maryvale Homestead or from the community of Titijikala due to intervening topography (views from the north would be blocked by Charlotte Range, refer to Sheet 3, Figure 17-3). Similarly, the proposed accommodation village would not be visible from Chambers Pillar, Chambers Pillar Historical Reserve or from Idracowra Homestead due to intervening topography (views from the south would be blocked by Maryvale Hills, refer to Sheet 1, Figure 17-3).

Mine infrastructure area (Chandler Facility)

Construction and operation of the proposed Chandler Facility would result in long term changes (25 plus years) to the existing landscape character of the area. Landscape impacts would arise as a result of above ground infrastructure required to support the underground salt mine. Without appropriate landscape and visual amenity mitigation in place, adverse impacts on the existing landscape would occur over the long term.

The proposed mine infrastructure area would not be visible from any of the identified sensitive visual receptors during operation of the Proposal. This would be due to the distance of the sensitive visual receptors from the proposed mine infrastructure area and due to intervening topography. Henbury Homestead and Palmer Valley Homestead are located over 72 kilometres to the west of the proposed mine infrastructure area (well outside of the zone of theoretical visibility). At these distances, the proposed mine infrastructure area would not be visible. In addition, the proposed mine infrastructure area would not be visible from Maryvale Homestead or from the community of

Titjikala due to intervening topography (views from the north would be blocked by Charlotte Range, refer to Sheet 3, Figure 17-3). Similarly, the proposed mine infrastructure area would not be visible from Chambers Pillar, Chambers Pillar Historical Reserve or from Idracowra Homestead due to intervening topography (views from the south would be blocked by Maryvale Hills, refer to Sheet 1, Figure 17-3).

Apirnta Facility

Construction and operation of the proposed Apirnta Facility would result in long term changes 925 plus years) to the existing landscape character of the area. Landscape impacts would arise as a result of above ground infrastructure required to support the Chandler Facility. Without appropriate landscape and visual amenity mitigation in place, adverse impacts on the existing landscape would occur over the long term.

It is possible that transient views of the proposed Apirnta Facility could be seen from within a train travelling north or south along the Central Australian Railway. These views would be of a short duration and screened by existing vegetation. Therefore, the visual impacts are considered to be minor. Mitigation and management measures to reduce this potential impact are discussed in Section 17.7.

The proposed Apirnta Facility would not be visible from any of the other identified sensitive visual receptors during operation of the Proposal. This would be due to the distance of the sensitive visual receptors from the proposed Apirnta Facility and due to intervening topography. Henbury Homestead and Palmer Valley Homestead are located over 45 kilometres to the west of the proposed Apirnta Facility (well outside of the zone of theoretical visibility). Maryvale Homestead and the community of Titjikala are also located over 39 kilometres to the east of the proposed Apirnta Facility (also well outside of the zone of theoretical visibility).

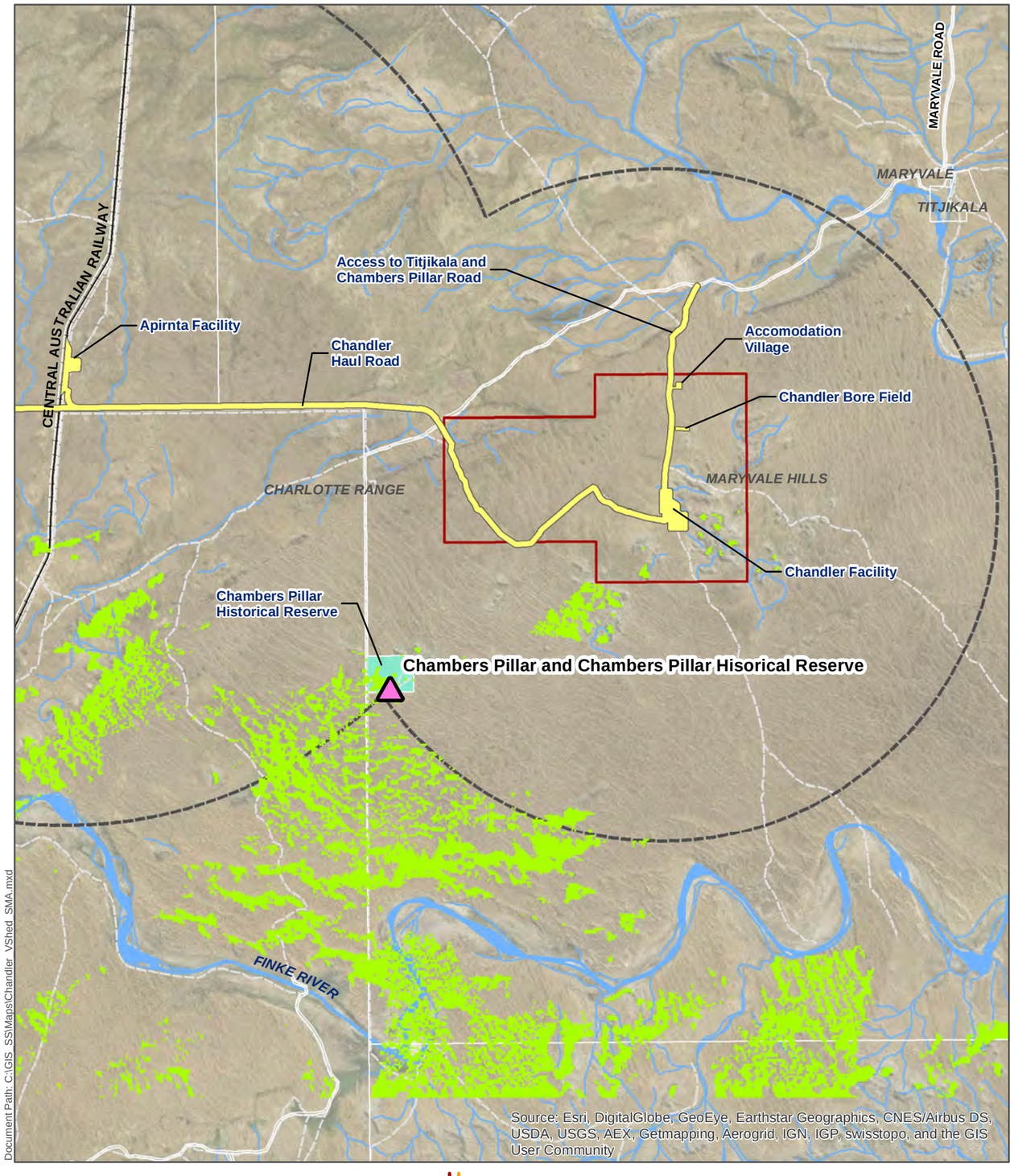
At these distances, the proposed Apirnta Facility would not be visible (refer to Sheet 3, Figure 17-3). In addition, the proposed Apirnta Facility would not be visible from the Chambers Pillar, Chambers Pillar Historical Reserve or from Idracowra Homestead due to intervening topography (views from the south would be blocked by Maryvale Hills, refer to Sheet 1, Figure 17-3).

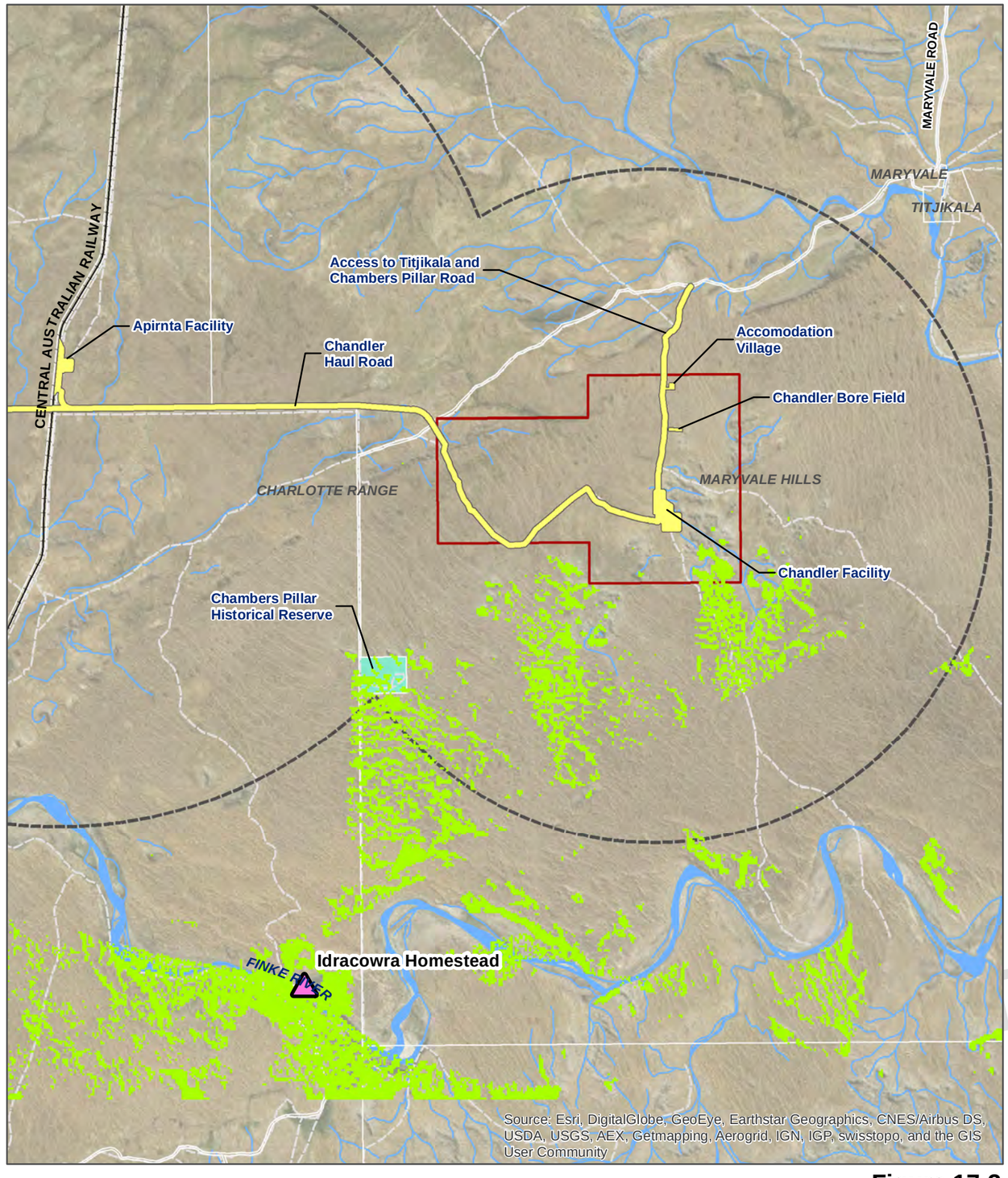
Chandler Haul Road and Henbury Access Road

Two existing access tracks located within the proposed development footprint would be converted into the proposed Henbury Access Road and Chandler Haul Road. The existing access tracks would be widened but would be constructed of the same materials as the existing access tracks. Therefore, there would be little change to the existing landscape character in the vicinity of the proposed Henbury Access Road and Chandler Haul Road.

Transient views of the proposed Henbury Access Road and Chandler Haul Road would likely be visible from the Central Australian Railway and from Chambers Pillar Road during operation of the Proposal. The proposed Henbury Access Road and Chandler Haul Road would likely not be visible from any of the other identified sensitive visual receptors during operation of the Proposal. This

would be due to the distance of the sensitive visual receptors from the proposed Henbury Access Road and Chandler Haul Road and due to intervening topography that would block views from the sensitive visual receptors to the proposed Henbury Access Road and Chandler Haul Road (specifically, Charlotte Range and Maryvale Hills).





Document Path: C:\GIS_SSIMaps\Chandler_VShed_SMA.mxd

N

5 2.5 0 5 Kilometers

Coordinate System:
GDA 1994 MGA Zone 53

Legend

- Existing road
- Existing track
- Watercourse
- ML30612
- Proposed development footprint
- Landscape visible from sensitive visual receptor
- Zone of visual influence
- Sensitive visual receptor

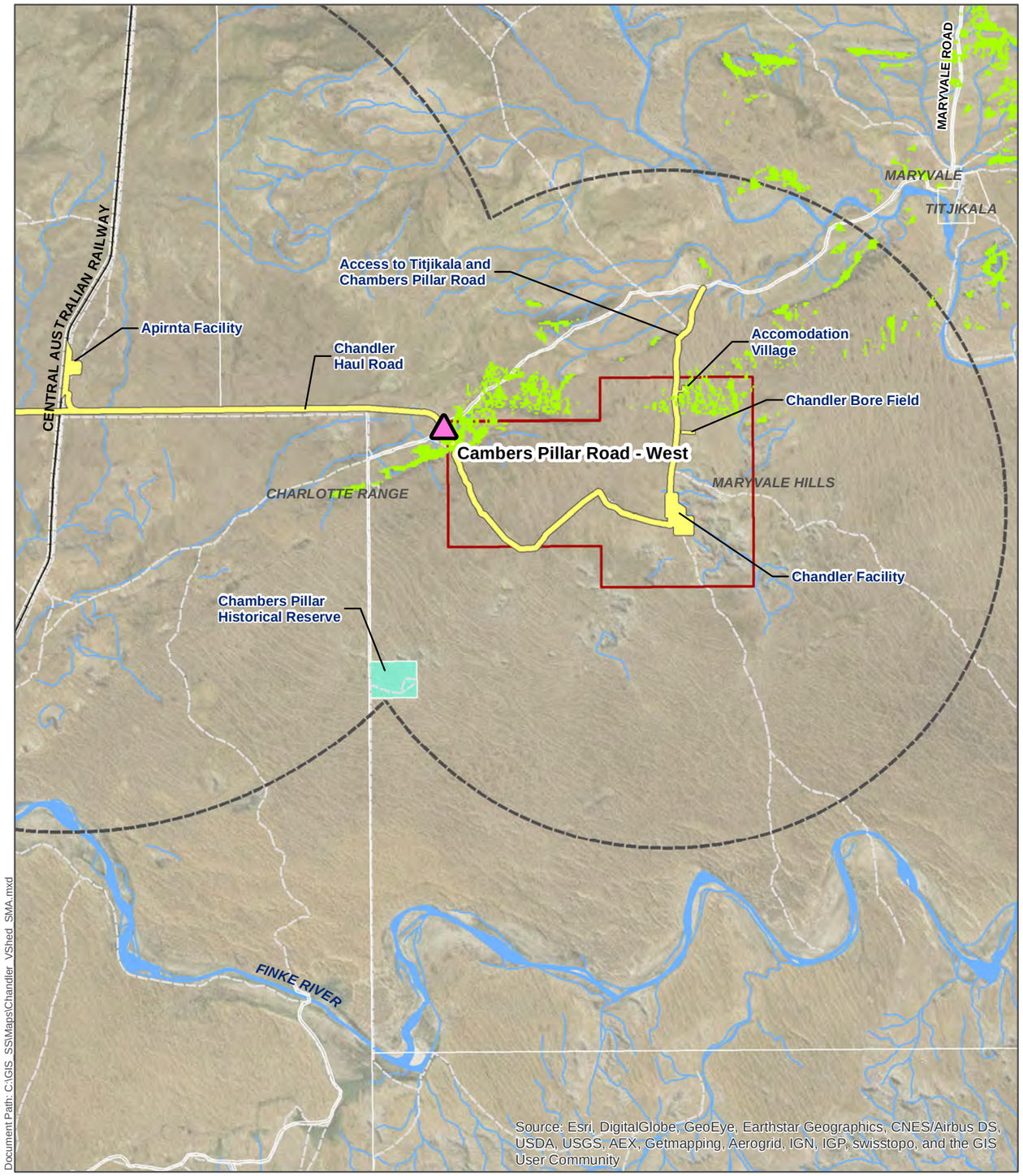
Figure 17-3

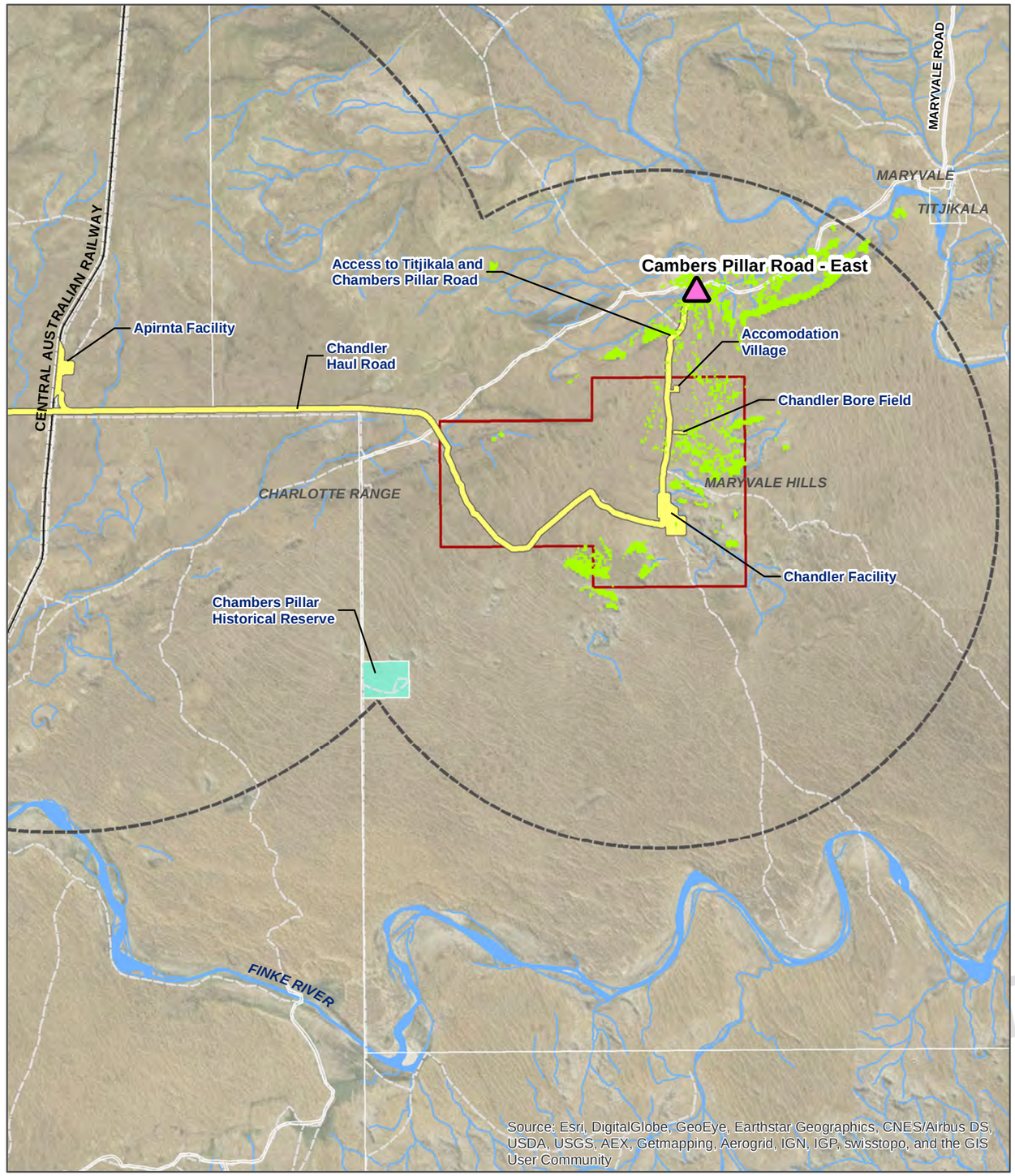
Viewshed analysis (Sheet 1) - Chambers Pillar and Chambers Pillar Historical Reserve and Idracowra Homestead

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.





Document Path: C:\GIS_SSIMaps\Chandler_VShed_SMA.mxd

5 2.5 0 5 Kilometers

N

Coordinate System:
GDA 1994 MGA Zone 53

Legend

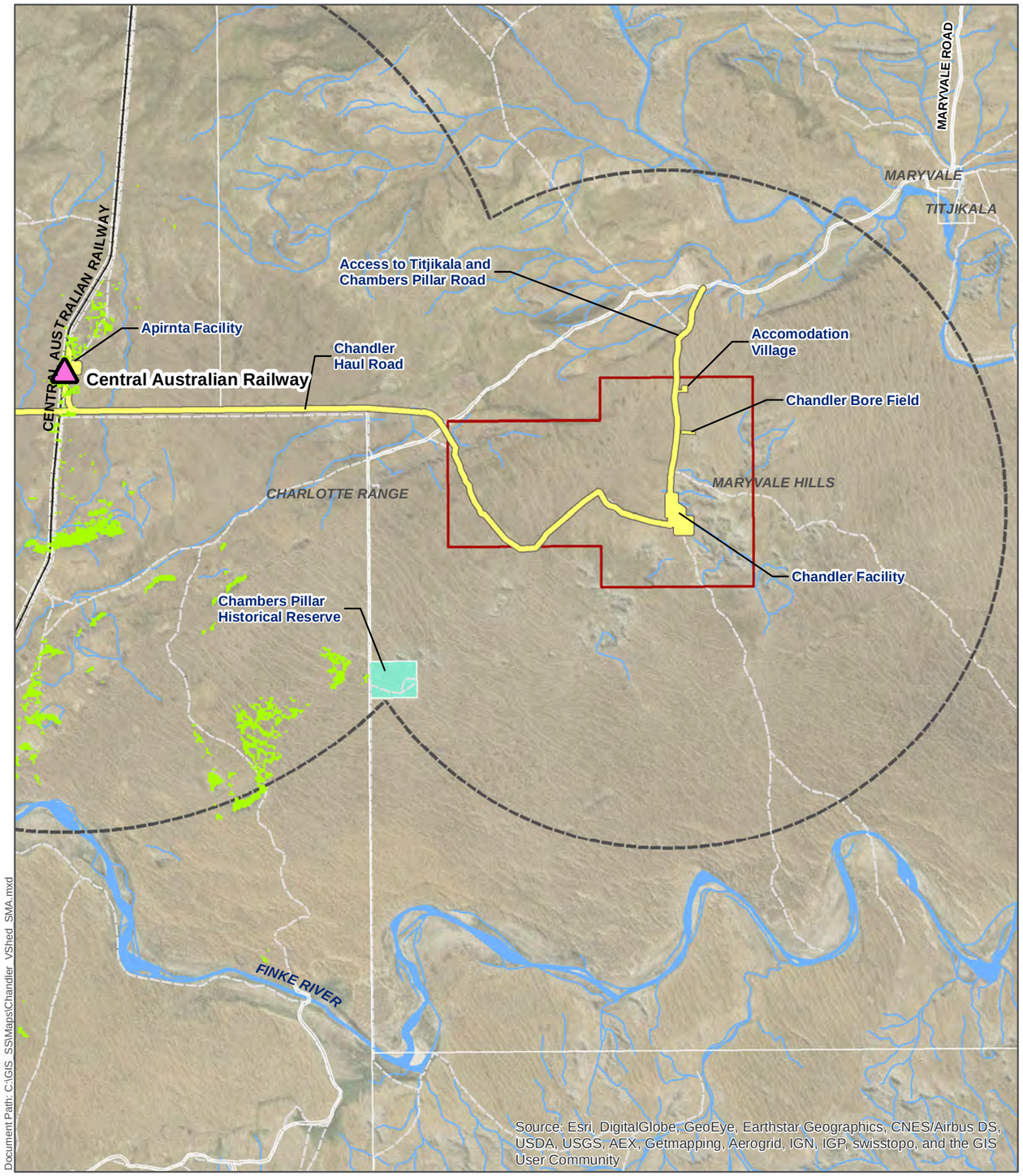
- Existing road
- Existing track
- Watercourse
- ML30612
- Proposed development footprint
- Landscape visible from sensitive visual receptor
- Zone of visual influence
- Sensitive visual receptor

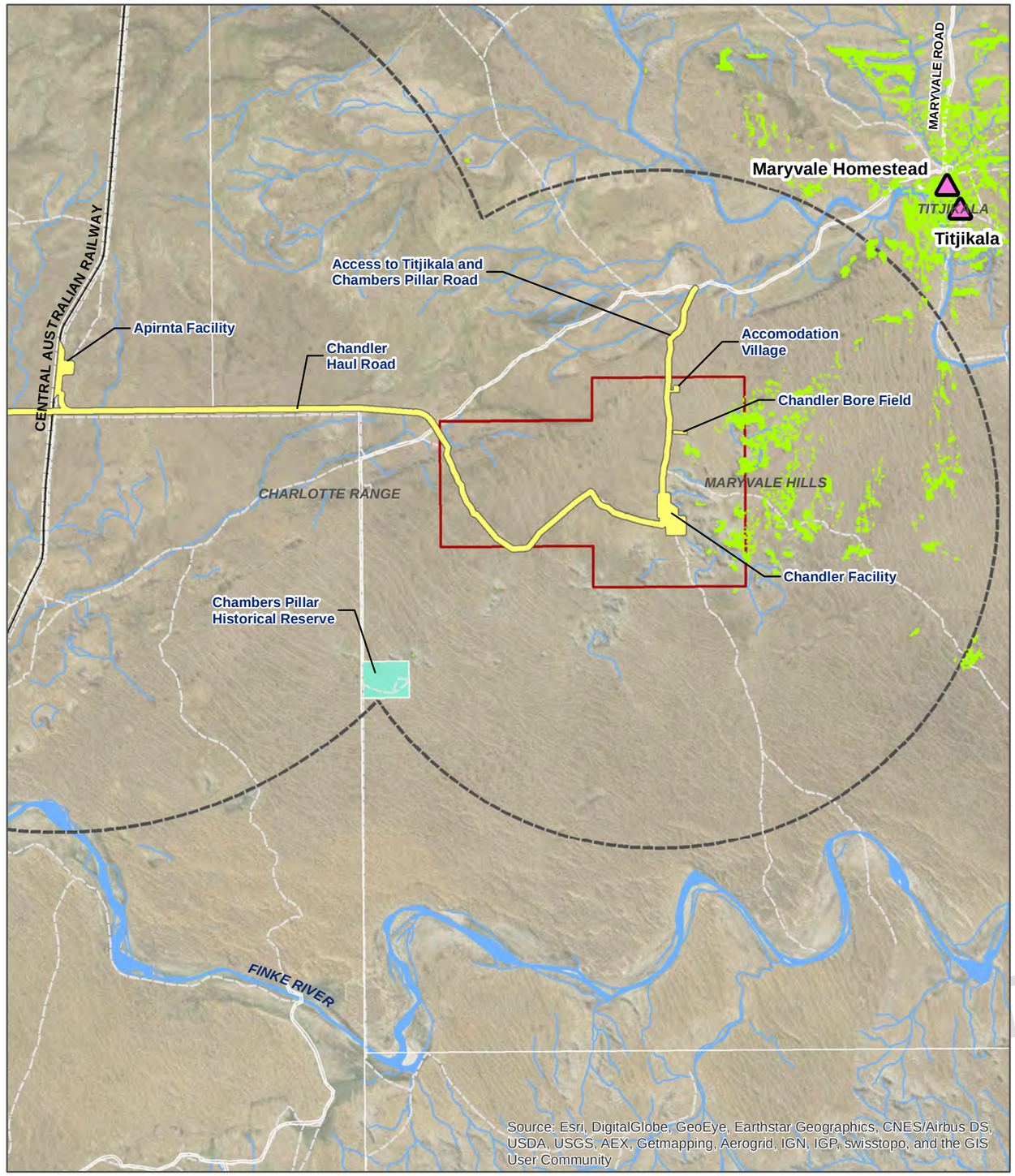
Figure 17-3
Viewshed analysis (Sheet 2) - Chambers Pillar Road

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use.
Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.





Document Path: C:\GIS_SSIMaps\Chandler_VShed_SMA.mxd

N

5 2.5 0 5 Kilometers

Coordinate System:
GDA 1994 MGA Zone 53

Legend

- Existing road
- Existing track
- Watercourse
- ML30612
- Proposed development footprint
- Landscape visible from sensitive visual receptor
- Zone of visual influence
- Sensitive visual receptor

Figure 17-3
Viewshed analysis (Sheet 3) - Central Australian Railway
Titjikala and Maryvale Homestead

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use.
Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.

17.5.2 Indirect impacts

Permanent changes to the landscape and the degree of contrast or integration of new features with existing or remaining landscape elements and characteristics may adversely impact cultural values associated with country for Traditional Owners. Therefore, judging the magnitude of the visual effects in terms of the relative amount of time over which it would be experienced, and whether views would be full, partial or glimpses, is at this stage of pre-development considered a moderate impact requiring further investigation during detailed design.

17.6 Closure and rehabilitation

Closure would involve the removal of all above ground infrastructure. Rehabilitation would follow the requirements of a RCP (refer to Chapter 13). The visual impacts associated with closure and rehabilitation would be similar to those during construction of the Proposal.

It is possible that transient views of closure and rehabilitation activities associated with the proposed Apirnta Facility could be seen from within a train travelling north or south along the Central Australian Railway. It is also possible that transient views of closure and rehabilitation activities associated with the proposed accommodation village could be seen from vehicles travelling along Chambers Pillar Road. These views would be of a short duration and likely screened by existing vegetation. Therefore, the visual impacts are considered to be minor.

The closure and rehabilitation works would not be visible from Maryvale Homestead, the community of Titjikala, Chambers Pillar, Chambers Pillar Historical Reserve, Idracowra Homestead, Palmer Valley Homestead, or Henbury Homestead. This would be due to the distance of the sensitive visual receptors from the proposed closure and rehabilitation works and/or due to intervening topography that would block views from the sensitive visual receptors to the proposed closure and rehabilitation works (predominately, the Charlotte Range and Maryvale Hills).

17.7 Mitigation and monitoring

Mitigation and management measures proposed to minimise the impacts on visual amenity during construction, operation, and closure and rehabilitation of the Proposal are listed in Table 17-2. These measures would be incorporated into the CEMP, OEMP and/or RCP for the Proposal.

17.8 Summary of risk assessment

A summary of the risk assessment undertaken for visual impact assessment during construction, operation, and closure and rehabilitation of the Proposal is provided in Table 7-12.

Table 17-2 Summary of risk assessment (visual)

Hazard	Pre-mitigated risk			Post-mitigated risks			Risk outcome
	Likelihood	Consequence	Risk ranking	Likelihood	Consequence	Risk ranking	
Visibility of above ground infrastructure	Almost certain	Minor	High	Unlikely	Minor	Low	Risk reduced
Visibility of decline entry	Almost certain	Minor	High	Unlikely	Minor	Low	Risk reduced
Visibility of spoil stockpiles	Almost certain	Minor	High	Unlikely	Minor	Low	Risk reduced
Visibility of run of mine salt stockpile	Almost certain	Minor	High	Unlikely	Minor	Low	Risk reduced
Visibility of detention/sediment ation ponds	Almost certain	Minor	High	Unlikely	Minor	Low	Risk reduced
Visibility of access roads	Almost certain	Minor	High	Unlikely	Minor	Low	Risk reduced
Visibility of accommodation village	Almost certain	Minor	High	Unlikely	Minor	Low	Risk reduced
Subsidence causing changes to land form	Unlikely	Moderate	Medium	Unlikely	Minor	Low	Risk reduced

Table 17-3 Mitigation and management measures (landscape and visual amenity)

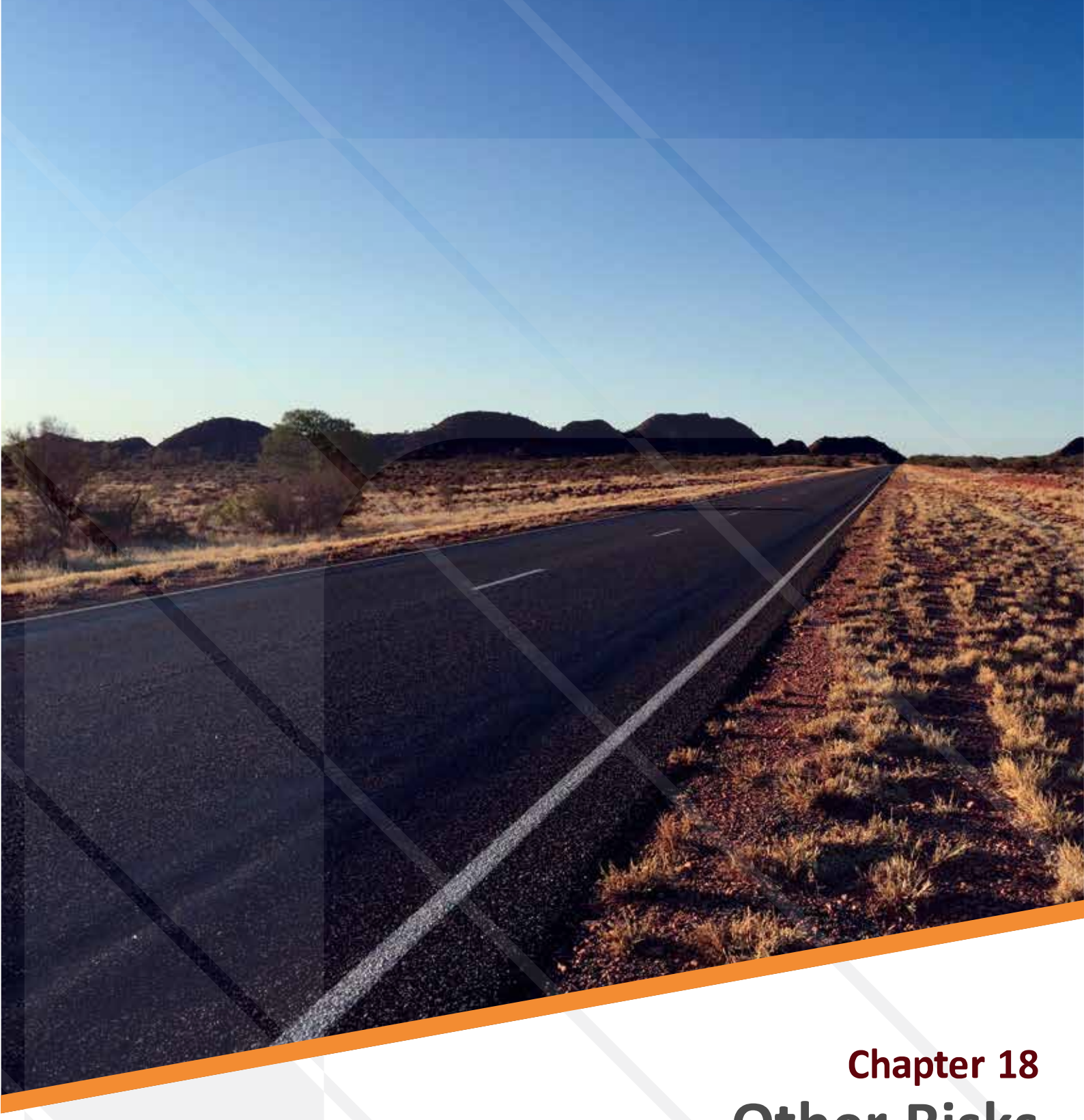
ID	Outcome	Mitigation/management measure	Timing
LV.1	Landscape management	Prepare a Landscape Concept Plan as part of the detailed design of the Proposal. Measures in the plan would include the consideration of existing landscape features when siting infrastructure and choosing building materials and treatments to minimise the potential visibility of the Proposal.	Detailed design
LV.2	Avoid visual impacts on potential items of cultural sensitivity	Consult with Traditional Owners during the detailed design of the Proposal.	Detailed design
LV.3	Screening of infrastructure	Where possible, utilise existing features of the landscape, such as existing shrubs and trees, to screen and minimise visual impacts of infrastructure and/or permanent structures.	Detailed design
LV.4	Complement the existing landscape	Choose external building finishes to minimise visual impact. Recessive, low reflectivity finishes that blend with the adjoining bushland wold be used. Roof colours and finishes would complement the colour of the building facades and the hues would aim to blend with the colours prevailing in the surrounding landscape.	Detailed design
LV.5	Minimise the impact of uncharacteristic features in the landscape	Avoid the use of highly reflective surfaces/colours, brightly coloured or strongly contrasting materials, and unpainted metal.	Detailed design
LV.6	Minimise the impact of uncharacteristic features in the landscape	Ensure boundary fences are simple, non-reflective and have a high degree of transparency.	Detailed design
LV.7	Mitigate plant loss and screening of infrastructure	Plant trees (in accordance with the recommendations of the Biodiversity Management Plan) to reduce the visual impacts of the Proposal. Tree planting would give scale to the buildings, provide amenity (shade) for employees, and screen areas, such as stockpiles and hardstand areas.	Prior to operation
LV.8	Provide future ecological opportunities	Ensure native and endemic species are used during tree planting to ensure that the existing landscape character is retained.	Prior to operation
LV.9	Avoidance of bushfires	Ensure trees are planted on the perimeter of hardstand areas and out of the bushfire buffer zones.	Construction and operation

17.9 Conclusion

It is possible that transient views of the proposed accommodation village could be seen from vehicles travelling along Chambers Pillar Road during construction, operation, and closure and rehabilitation of the Proposal. It is also possible that transient views of the proposed Apirnta Facility could be seen from within a train travelling north or south along the Central Australian Railway during construction, operation, and closure and rehabilitation of the Proposal. These views would be of a short duration and likely screened by existing vegetation. Therefore, the visual impacts are considered to be minor. Mitigation and management measures would be implemented to reduce these potential impacts.

None of the proposed infrastructure would be visible from Maryvale Homestead, the community of Titjikala, Chambers Pillar, Chambers Pillar Historical Reserve, Idracowra Homestead, Henbury Homestead or Palmer Valley Homestead during construction, operation or during closure and rehabilitation of the Proposal. This would be due to the distance of the sensitive visual receptors from the proposed infrastructure and due to intervening topography, that blocks views from the sensitive visual receptors to the proposed infrastructure (predominantly, Charlotte Range and the Maryvale Hills).

The proposed above ground infrastructure would be long term features within the existing landscape. Without appropriate landscape and visual amenity measures in place, this is considered to have a high visual impact on the existing landscape character and visual amenity of the area. Mitigation and management measures identified in Table 17-2 would be implemented to minimise these impacts. These measures would also mitigate visual impacts that could apply to cultural heritage.



Chapter 18
Other Risks

TELLUS

This page has been left intentionally blank

18 OTHER RISKS

18.1 Public health and food

18.1.1 Introduction

This section discusses the requirements food safety, staff accommodation and sanitary facilities, on-site wastewater disposal, trade waste pre-treatment devices, potable water supply, bores, fuel storage, public health nuisance abatement, occupational health and safety and environmental management plans with regard to the NT Department of Health – Environmental Health *Environmental Fact Sheet No. 700: Requirements for Mining and Construction Projects* (2014a). The requirements for solid waste disposal, waste stabilisation ponds and radioactive sources are not addressed as they would not be applicable to the Proposal.

18.1.2 Food safety requirements

The proposed accommodation village is defined as a food business under the NT *Food Act*. It would, therefore, require registration with the NT Department of Helth – Environmental Health in accordance with the NT *Food Act*.

The proposed accommodation village would be designed to meet the minimum standards prescribed by the National Food Safety Standards prescribed by Food Standards Australia New Zealand. These standards include:

- Standard 3.1.1 Interpretation and Application.
- Standard 3.2.2 Food Safety Practices and General Requirements.
- Standard 3.2.3 Food Premises and Equipment.

It would also be designed in accordance with Australian Standard (AS) 4674 *Design, Construction and Fit-out of Food Premises.* Food premises that meet the requirements contained within AS 4674 are deemed to comply with the NT *Food Act* and the National Food Safety Standards.

The proposed accommodation village would be located outside of a Building Control Area, as mapped by the NT Department of Health – Environmental Health in *Environmental Fact Sheet No. 700: Requirements for Mining and Construction Projects* (2014a). As such, detailed plans and specifications of the accommodation village with regard to food safety would be submitted to the relevant Environmental Health Officer within the NT Department of Health prior to the construction. Following assessment and approval, and prior to operation, the accommodation village would be registered with the relevant Environmental Health Office.

18.1.3 Staff accommodation and sanitary facilities

All public accommodation including staff accommodation must be maintained in a good state of repair and in a clean and sanitary condition so as not to cause a public health nuisance in accordance

with the NT *Public and Environmental Health Act*. The general requirements for conducting a public accommodation business such as the need to prevent overcrowding and provide an acceptable standard of sanitation, amenity and safety are outlined in the NT Department of Health – Environmental Health *Public and Environmental Health Guidelines for Public Accommodation* (2014b).

The proposed accommodation village would be maintained in accordance with the NT *Public and Environmental Health Act* and with the requirements set out by NT Department of Health – Environmental Health in the *Public and Environmental Health Guidelines for Public Accommodation* (2014b). An adequate number of sanitary facilities would be provided at the proposed accommodation village in accordance with the Building Code of Australia.

As discussed above, the proposed accommodation village would be located outside of a Building Control Area, as mapped by the NT Department of Health – Environmental Health (2014a). As such, detailed plans and specifications of the accommodation village with regards to staff accommodation and sanitary facilities would be submitted to the relevant Environmental Health Officer within the NT Department of Health prior to the construction. Following assessment and approval, and prior to operation, the accommodation village would be registered with the relevant Environmental Health Office.

18.1.4 On-site wastewater disposal

Alternative septic tank systems treat effluent to a higher quality than that offered by conventional septic tank systems. An aerated wastewater treatment system is an example of an alternative septic tank system and would be installed at the proposed accommodation village. In addition to the self-certification of the installation, the aerated wastewater treatment system would require wastewater works design approval by the NT Department of Health – Environmental Health under the provisions of the NT *Public and Environmental Health Act* and Public and Environmental Health Regulations.

18.1.5 Trade waste pre-treatment devices

Trade waste is defined as a 'liquid or liquid borne waste generated from any industry, business, trade, manufacturing process or similar that is approved for discharge to sewer but does not include wastewater from a toilet, shower, hand basin or similar fixture' (NT Department of Health – Environmental Health 2014a). Commercial food premises at the accommodation village may prepare cooked food generating liquid waste that includes food scraps, detergents, fats, oils and grease.

Liquid trade waste generated at the proposed accommodation village would be discharged to sewer via a pre-treatment device(s) that have been approved by NT Power and Water Corporation – Trade Waste Section.

18.1.6 Potable water supply

A proposed bore field would be constructed approximately two kilometres to the north-east of the proposed Chandler Facility. Water extracted from bores at the borefield would be treated at a water

treatment plant for potable use (consumption) and for other domestic uses (the preparation of food, bathing, washing of clothes and dishes, etc.). Treatment processes may include reverse osmosis, ultraviolet sterilisation, chlorination, or others, as required. The water would be routinely analysed to ensure that it meets the requirements of the *Australian Drinking Water Guidelines (2011) – Updated February 2016* developed by the by the National Health and Medical Research Council in collaboration with the Natural Resource Management Ministerial Council. In addition, a general chemical and metals analysis would also be routinely undertaken.

18.1.7 Bores

Bores within the borefield would be constructed to the standards outlined in the *Minimum Construction Requirements for Water Bores in Australia, Third Edition* (Australian Government National Water Commission 2012). Bore setbacks to on-site wastewater disposal would be in accordance with the NT *Code of Practice for On-site Wastewater Management* (Environmental Health Program Directorate Territory Health Services 2014).

18.1.8 Fuel storage

Fuel, oil or hazardous materials would be stored on-site for general construction and operational activities. These materials would be stored in designated bunded area at the proposed Chandler Facility and at the proposed Apirnta Facility. These materials would be stored and handled on-site in accordance with AS 1940-2004 *Storage and Handling of Flammable and Combustible Liquids.*

18.1.9 Solid waste disposal

Solid waste would be collected in designated bins and trucked off-site to appropriately licenced waste facilities in Titjikala or Alice Springs, as appropriate. There would be no requirement for a solid waste landfill on-site. Opportunities for composting food waste would be explored during detailed design of the Proposal.

18.1.10 Public health nuisance abatement

Activities associated with construction, operation and closure and rehabilitation have the potential to result in air quality impacts (in the form of dust) and also impacts to groundwater and surface water. These impacts would be avoided or reduced by implementing the mitigation measures outlined in Chapter 8, Chapter 9 and Chapter 15.

18.1.11 Occupational health and safety

Activities associated with construction, operation, and rehabilitation and decommissioning would be carried out in accordance with occupational health and safety legislation administered by NT WorkSafe and in accordance with a Safety Case[32].

18.1.12 Environmental management plans

The sections of the CEMP as they relate to the accommodation village would be provided to the relevant Environmental Health Office for review and comment prior to construction. Similarly, the sections of the OEMP as they relate to the accommodation village would be provided to the Environmental Health Office for review and comment prior to operation.

18.1.13 Mitigation and monitoring

The Proposal would be designed, constructed and operated in accordance with the requirements set out in the NT Department of Health – Environmental Health *Environmental Fact Sheet No. 700: Requirements for Mining and Construction Projects* (2014a). These requirements are listed in Table 18-1. These requirements would be incorporated into the CEMP, OEMP and RCP for the Proposal.

18.1.14 Conclusion

The Proposal would be designed, constructed and operated in accordance with the requirements set out in the NT Department of Health – Environmental Health *Environmental Fact Sheet No. 700: Requirements for Mining and Construction Projects* (2014a). Specifically, the requirements for food safety, staff accommodation and sanitary facilities, on-site wastewater disposal, trade waste pre-treatment devices, potable water supply, bores, fuel storage, public health nuisance abatement, occupational health and safety and environmental management plans would be adhered to. The requirements for solid waste disposal, waste stabilisation ponds and radioactive sources are not addressed as they would not be applicable to the Proposal.

[32] *Note – Following submission and approval of the Proposal, the proponent would prepare and submit a Safety Case report to NT WorkSafe.*

Table 18-1 Mitigation and management measures (public health and food)

ID	Outcome	Mitigation/management measure	Timing
PHF.1	Adherence with the environmental health requirements of the NT Department of Health – Environmental Health.	Design, construct and operate the Proposal in accordance with the requirements set out in the NT Department of Health – Environmental Health *Environmental Fact Sheet No. 700: Requirements for Mining and Construction Projects* (2014).	Pre-construction, construction and operation
PHF.2	Adherence with food safety requirements of the NT Department of Health – Environmental Health.	Register the proposed accommodation village with the NT Department of Health – Environmental Health in accordance with the NT *Food Act.*	Pre-construction
PHF.3	Adherence with food safety requirements of the NT Department of Health – Environmental Health.	Design accommodation village to meet the minimum standards prescribed by the National Food Safety Standards prescribed by Food Standards Australia New Zealand and in accordance with Australian Standard (AS) 4674 *Design, Construction and Fit-out of Food Premises.*	Pre-construction
PHF.4	Adherence with food safety requirements of the NT Department of Health – Environmental Health.	Submit detailed plans and specifications of the accommodation village with regard to food safety (prior to construction) to the relevant Environmental Health Officer within the NT Department of Health.	Pre-construction
PHF.5	Adherence with food safety requirements of the NT Department of Health – Environmental Health.	Register accommodation village following assessment and approval (prior to operation) with the relevant Environmental Health Office.	Pre-operation
PHF.6	Adherence with staff accommodation and sanitary facilities requirements of the NT Department of Health – Environmental Health.	Maintain accommodation village in accordance with the NT *Public and Environmental Health Act* and with the requirements set out by NT Department of Health – Environmental Health in the *Public and Environmental Health Guidelines for Public Accommodation* (2014).	Operation
PHF.7	Adherence with staff accommodation and sanitary facilities requirements of the NT Department of Health – Environmental Health.	Provide an adequate number of sanitary facilities at the proposed accommodation village in accordance with the Building Code of Australia.	Operation
PHF.8	Adherence with staff accommodation and sanitary facilities requirements of the NT Department of Health – Environmental Health.	Submit detailed plans and specifications of the accommodation village with regard to staff accommodation and sanitary facilities (prior to construction) to the relevant Environmental Health Officer within the NT Department of Health.	Pre-construction
PHF.9	Adherence with staff accommodation and sanitary facilities requirements of the NT Department of Health – Environmental Health.	Register accommodation village following assessment and approval (prior to operation) with the relevant Environmental Health Office.	Pre-operation

ID	Outcome	Mitigation/management measure	Timing
PHF.10	Adherence with on-site wastewater disposal requirements of the NT Department of Health – Environmental Health.	Submit aerated wastewater treatment system for wastewater works design approval by the NT Department of Health – Environmental Health in accordance with the provisions of the NT *Public and Environmental Health Act* and Public and Environmental Health Regulations.	Pre-construction
PHF.11	Adherence with on-site wastewater disposal requirements of the NT Department of Health – Environmental Health.	Obtain approval for liquid trade waste pre-treatment device(s) at the accommodation village from the NT Power and Water Corporation – Trade Waste Section.	Pre-construction
PHF.12	Adherence with potable water supply requirements of the NT Department of Health – Environmental Health.	Potable water would be routinely analysed to ensure that it meets the requirements of the *Australian Drinking Water Guidelines (2011) – Updated February 2016* developed by the by the National Health and Medical Research Council in collaboration with the Natural Resource Management Ministerial Council. In addition, a general chemical and metals analysis would also be routinely undertaken.	Construction and operation
PHF.13	Adherence with bores requirements of the NT Department of Health – Environmental Health.	Ensure that bores within the borefield are constructed to the standards outlined in the *Minimum Construction Requirements for Water Bores in Australia, Third Edition* (Australian Government National Water Commission 2012).	Pre-construction
PHF.14	Adherence with bores requirements of the NT Department of Health – Environmental Health.	Ensure that bore setbacks to on-site wastewater disposal would be in accordance with the NT *Code of Practice for On-site Wastewater Management* (Environmental Health Program Directorate Territory Health Services 2014).	Pre-construction
PHF.15	Adherence with fuel storage requirements of the NT Department of Health – Environmental Health.	Ensure that fuels are stored and handled on-site in accordance with AS 1940-2004 *Storage and Handling of Flammable and Combustible Liquids.*	Construction, operation, and closure and rehabilitation
PHF.16	Responsible disposal of solid waste.	Solid waste would be collected in designated bins and trucked off-site to appropriately licenced waste facilities in Titjikala or Alice Springs, as appropriate.	Construction, operation, and closure and rehabilitation
PHF.17	Reduce off-site disposal of food waste.	Explore opportunities for composting food waste during detailed design of the Proposal.	Construction
PHF.18	Adherence with public health nuisance abatement requirements of the NT Department of Health – Environmental Health.	Implement mitigation measures listed under groundwater, surface water and air quality.	Construction, operation, and

ID	Outcome	Mitigation/management measure	Timing
			closure and rehabilitation
PHF.19	Adherence with occupational health and safety requirements of the NT Department of Health – Environmental Health.	Ensure that activities associated with construction, operation, and closure and rehabilitation are carried out in accordance with occupational health and safety legislation administered by NT WorkSafe and in accordance with the Safety Case.	Construction, operation and, and closure and rehabilitation
PHF.20	Adherence with environmental management plan requirements of the NT Department of Health – Environmental Health.	Provide relevant sections of the CEMP and OEMP to the Environmental Health Office for review and comment prior to construction and operation.	Pre-construction and pre-operation

18.2 Biting insects

18.2.1 Introduction

This section describes the likelihood of occurrence of biting insects (specifically mosquitos) within the proposed development footprint and vicinity. The potential to possibly increase the mosquito population within the proposed development footprint and vicinity through the development of favourable breeding environments is presented. This section also presents mitigation measures to prevent an increase in biting insects within the proposed development footprint and vicinity and to protect personnel during construction, operation, and closure and rehabilitation of the Proposal.

18.2.2 Existing environment

The presence of biting insects within the proposed development footprint and vicinity is highly variable and dependent on breeding conditions determined by warm seasonal rainfall. The existing surface hydrology of the proposed development footprint and vicinity consists of ephemeral watercourses, claypans, swamps and a purpose-built pastoral dam called Halfway Dam. Halfway Dam is the only permanent surface water source located in the region.

There are two major ephemeral watercourses located more than 20 kilometres from the proposed Chandler Facility (the Hugh River and Finke River).

Claypans and swamps occur mostly on the downstream side of the proposed Chandler Haul Road and at various locations along the proposed Henbury Access Road. Duck Swamp is located approximately one kilometre north and east of the proposed Henbury Access Road. Swamps and claypans can retain surface water for hours or days at a time depending on the duration of rainfall and volume of water received within the local sub-catchment.

Surface waterholes can be found for a small amount of time after rainfall in creek lines, drainage depressions and claypans. The proposed development footprint and vicinity experiences evaporation rates in excess of three metres per annum, consequently water holes dry quickly during the summer.

A number of mosquito species, several of which have the potential to cause discomfort and others that have the potential to carry disease, are likely to occur within the proposed development footprint or vicinity. These species are listed in Table 18-2.

Table 18-2 Species of mosquitos likely to occur within the proposed development footprint or vicinity

Scientific name	Common name	Breeding places	Disease potential	Likelihood of occurrence
Aedes notoscriptus	Receptacle mosquito	Tree holes, rock pools, fallen palm fronds and rain filled receptacles.	Suspected vector of Ross River virus.	Likely
Aedes tremulus	Pale larvae mosquito	Holes in trees/stumps and artificial receptacles.	Not known to carry diseases in Australia.	Likely
Culex annulirostris	Common banded mosquito	Freshwater swamps, vegetated streams, storm water drains, grassy edges of sewage ponds, inundated low lying grassy areas. It has been found in brackish water, although is not usually found in areas exceeding one third salt water.	Vector of Murray Valley encephalitis virus in Australia, capable of carrying Kunjin virus, Ross River virus and Barmah Forest virus.	Recorded during biodiversity field surveys in the riparian zone along the Finke River in 2015. Likely widespread.
Culex quinquefasciatus	Brown house mosquito	Septic tanks, stormwater drains, sumps, gully traps and any artificial receptacle holding water.	Low	Likely

Source: Whelan, 2010.

18.2.3 Assessment of risk during construction, operation, and closure and rehabilitation

Activities associated with construction and operation of the Proposal have the potential to effect and possibly increase the mosquito population within the proposed development footprint and vicinity through the development of favourable breeding environments.

The creation of infrastructure such as surface water retention ponds, drainage swales, check dams and weirs could provide mosquito breeding habitat within the proposed development footprint or vicinity, although none of these would have standing water for very long given the high evaporation rates (in excess of three metres per annum) in the area. Artificial receptacles such as containers, tins, tyres or drums could also create favourable breeding environments after rainfall events.

18.2.4 Mitigation and monitoring

Mitigation and management measures proposed to prevent an increase in biting insects within the proposed development footprint and vicinity and to protect personnel during construction, operation, and closure and rehabilitation of the Proposal are listed in Table 18-3. These measures would be incorporated into the CEMP, OEMP and RCP for the Proposal. A draft Biting Insect Management Plan has also been prepared. This is included in Appendix Y.

The mitigation and management measures listed in Chapter 9 would be implemented to minimise alterations to the hydrology of the proposed development footprint and vicinity. This would, in turn, prevent an increase in biting insects within the proposed development footprint and vicinity.

Table 18-3 Mitigation and management measures (biting insects)

ID	Outcome	Mitigation/management measure	Timing
BI.1	Negligible increase in biting insects and protection of personnel from biting insects.	Finalise draft Biting Insect Management Plan prior to construction and incorporate into the CEMP and OEMP. The plan collates measures to mitigate and manage potential impacts on biodiversity.	Pre-construction
BI.2	Protection of personnel from biting insects.	Implement personnel protection measures in accordance with the NT Government Department of Health Guidelines *Personal Protection From Mosquitoes and Biting Insects in the NT*.	Construction, operation, closure and rehabilitation
BI.3	Negligible increase in biting insects.	Control and manage potential mosquito breeding sites in accordance with the NT Government Department of Health *Guidelines for Preventing Mosquito Breeding Sites Associated with Mining Sites.*	Construction, operation, closure and rehabilitation
BI.4	No ponding of water (no breeding habitat for mosquitos).	Ensure containers capable of ponding water are stored under cover, contain drainage holes, are emptied within five days, are treated with appropriate insecticide or disposed of appropriately according to the Waste Management Plan.	Construction, operation, closure and rehabilitation
BI.5	Protection of personnel from biting insects.	Ensure accommodation village is adequately screened.	Construction
BI.6	Negligible increase in biting insects.	Ensure no actual or potential mosquito breeding sites remain after decommissioning of the Proposal. Ensure disturbed areas are rehabilitated and free draining. Remove infrastructure that has the potential to pond water.	Closure and rehabilitation

18.2.5 Conclusion

The creation of infrastructure such as surface water retention ponds, drainage swales, check dams and weirs could provide mosquito breeding habitat within the proposed development footprint or vicinity, although none of these would have standing water for very long given the high evaporation rates (in excess of three metres per annum) in the area. Artificial receptacles such as containers, tins, tyres or drums may also create favourable breeding environments for biting insects after rainfall events.

Mitigation and management measures would be incorporated into a Biting Insect Management Plan to prevent an increase in biting insects within the proposed development footprint and vicinity and to protect personnel during construction, operation, and closure and rehabilitation of the Proposal.

18.3 Greenhouse gas assessment

18.3.1 Introduction

This section provides an assessment of greenhouse gas impacts during construction and operation of the Proposal. This section draws on a comprehensive greenhouse gas assessment provided in Appendix X.

18.3.2 Methodology

The methodology for the greenhouse gas assessment is summarised below with further detail provided in Appendix Y. The assessment encompassed a number of components including the proposed Chandler Facility and the Apirnta Facility. The assessment also considered the transfer of materials between the proposed Chandler Facility, Apirnta Facility and the Stuart Highway.

Activities performed during construction and operation with the potential to result in emissions of greenhouse gases were identified. The activity rate for each of these activities (e.g. kilolitres of fuel used per annum, hectares of land to be cleared) was subsequently calculated, or was based on clearly defined assumptions.

Emission factors for each activity were sourced from the *National Greenhouse Accounts Factors, Australian National Greenhouse Accounts* (Department of the Environment 2015). Other appropriate documentation was also used which allowed for the calculation of direct emissions (e.g. land clearance or fuel combustion) and indirect emissions (e.g. extraction and processing of fuels).

Emissions were calculated for each activity and are provided as annual total emissions for the construction and operation of the Proposal.

18.3.3 Assessment of risk during construction and operation

Direct emissions during construction are calculated to be 13,205.5 t CO_2-e per year with over half of emissions due to land clearance activities that would be undertaken during construction of the proposed Henbury Access Road and Chandler Haul Road. During operation, direct emissions are calculated to be 104,310.2 t CO_2-e per year.

Indirect emissions are calculated to be minor during construction at 155.0 t CO_2-e per year with emissions during operation anticipated to be 5,351.4 t CO_2-e per year.

These data indicate that the construction of the Proposal in its entirety would contribute up to 0.1% of total greenhouse gas emissions in the NT and up to 0.002% of total greenhouse gas emissions in Australia when compared to a base year of 2014. Operation of the Proposal in its entirety is anticipated to contribute up to 0.8% of total greenhouse gas emissions in the NT and up to 0.02% of total greenhouse gas emissions in Australia when compared to a base year of 2014.

18.3.4 Mitigation and monitoring

Mitigation and management measures proposed to reduce greenhouse gas emissions during construction, operation, and closure and rehabilitation of the Proposal are listed in Table 18-4. These measures would be incorporated into the CEMP, OEMP and RCP for the Proposal.

A number of sustainability measures would be incorporated into the design of the Proposal. For example, solar energy would be used to supplement the power requirements of the proposed Chandler Facility and Apirnta Facility (a two megawatt solar farm would be installed at the proposed Chandler Facility). These measures would ensure that greenhouse gas emissions are minimised to the maximum extent possible.

During detailed design, the proponent would investigate options for participation in the DoEE Emissions Reduction Fund.

Table 18-4 Mitigation and management measures (greenhouse gases)

ID	Outcome	Mitigation/management measure	Timing
GHG.1	Minimise greenhouse gas emissions.	Ensure vehicles/plant and machinery are turned off when not in use and regularly serviced to ensure efficient operation.	Construction, operation, closure and rehabilitation
GHG.2	Minimise greenhouse gas emissions.	Design truck routes and loading capacity to reduce the distance and effort required by vehicles.	Construction
GHG.3	Minimise greenhouse gas emissions.	Use B5 and E10 fuel in plant and equipment, where possible.	Construction, operation, closure and rehabilitation
GHG.4	Minimise greenhouse gas emissions.	Perform regular energy and water audits.	Operation
GHG.5	Minimise greenhouse gas emissions.	Install window blinds in all office areas.	Construction
GHG.6	Minimise greenhouse gas emissions.	Maximise the area covered by the solar farm to minimise fuel used in electricity generation.	Construction
GHG.7	Minimise greenhouse gas emissions.	Install sensor lighting to minimise the number of lights being operated when not required.	Construction
GHG.8	Minimise greenhouse gas emissions.	Use, energy efficient lighting, where possible.	Construction
GHG.9	Minimise greenhouse gas emissions.	Develop building maintenance policies and a building user guide to ensure efficient operation of plant and equipment.	Operation
GHG.10	Minimise greenhouse gas emissions.	Develop heating, ventilation and air conditioning key performance indicators and building performance targets.	Operation

ID	Outcome	Mitigation/management measure	Timing
GHG.11	Minimise greenhouse gas emissions.	Ensure sub-metering is in place to monitor electricity and water consumption throughout the Proposal.	Operation

18.3.5 Conclusion

The assessment presents an estimate of the greenhouse gas emissions which would be produced during both the construction and operation of the Proposal. The estimates indicate that the Proposal would contribute less than 1% of total greenhouse gas emissions in the NT, and 0.02% of total greenhouse gas emissions in Australia, when compared to a base year of 2014.

Sustainability would be a key consideration in the design, construction and operation of the Proposal. Inclusion of a two megawatt solar farm, use of energy efficient plant and equipment and a number of other measures would be incorporated into the Proposal to ensure that greenhouse gas emissions are minimised to the maximum extent possible.

During detailed design, the proponent would investigate options for participation in the DoEE Emissions Reduction Fund.

18.4 Traffic

18.4.1 Introduction

This section describes the existing road and rail traffic and transportation network within the vicinity of the Proposal. The potential for road and rail traffic and transportation impacts is discussed and mitigation measures are presented to reduce potential traffic and transportation impacts during construction, operation, and closure and rehabilitation of the Proposal.

18.4.2 Methodology

A qualitative assessment of road and rail traffic and transportation impacts was undertaken given the spare capacity of the existing road and rail network and the low numbers of road and rail traffic that would be generated during construction, operation, and closure and rehabilitation of the Proposal.

Road traffic count data was obtained from the NT Department of Transport. Rail traffic count data was obtained from Genesee Wyoming.

Estimates of road and rail traffic generated during construction, operation, and closure and rehabilitation were calculated based on a prefeasibility study undertaken by the proponent for the Proposal.

For the purposes of this assessment, a vehicle movement was defined as a one-way trip (that is, a return trip would be two vehicle movements).

18.4.3 Existing environment

Existing road and rail network

The existing road and rail network in the vicinity of the Proposal is shown in Figure 18-1. A description of the road network is as follows:

- **Access tracks**. There are a number of unpaved access tracks located within the proposed development footprint and vicinity that are currently used by the operators of Maryvale Station and Henbury Station. Two of these access tracks would be converted into the proposed Henbury Access Road and Chandler Haul Road.
- **Maryvale Road**. Maryvale Road is an unpaved public road 120 kilometres long that stretches between Alice Springs and the community of Titjikala. It is primarily used to access Maryvale Station and links to the Chambers Pillar Road. Sections of the Maryvale Road are used for the Finke Desert Race (refer to Plate 18-1). Some sections of Maryvale Road are prone to flooding during heavy rainfall. Following heavy rainfall and after the Finke Desert Race, the road is unusable and requires regrading.



Plate 18-1 Maryvale Road

- **Chambers Pillar Road**. Chambers Pillar Road is an unpaved public road that stretches between Maryvale Station to Chambers Pillar (refer to Plate 18-2). It is primarily used by station operators and tourists to access Chambers Pillar and the Chambers Pillar Nature Reserve located approximately 30 kilometres to the west of the Proposal.



Plate 18-2 Chambers Pillar Road (in the vicinity of where the proposed Chandler Haul Road would cross Chambers Pillar Road

- **Stuart Highway**. The Stuart Highway is one of Australia's major highways. It is approximately 2,834 kilometres in length and stretches from Darwin in the NT via Tennant Creek and Alice Springs to Port Augusta in South Australia. It is a paved, single-lane highway with speeds up to of 130 kilometres per hour in the vicinity of the Proposal (refer to Plate 18-1). Dangerous Goods are regularly transported from Adelaide to Darwin and vice versa along the Stuart Highway.



Plate 18-3 The Stuart Highway (in the vicinity of the proposed T-intersection at Henbury Access Road)

The Central Australian Railway is a north–south railway line that stretches approximately 1,420 kilometers between Darwin in the NT and Adelaide in South Australia. The railway is used to transport both freight and passengers. The Central Australian Railway is located approximately 60 kilometres to the east of the Stuart Highway in the vicinity of the Proposal. The proposed Apirnta Facility would be located adjacent to the Central Australian Railway (refer to Plate 18-2).



Plate 18-4 The Central Australian Railway (in the vicinity of the proposed Apirnta Facility)

Existing road and rail traffic volumes

2013 and 2014 Annual Average Daily Traffic (AADT) volumes along various sections of the Stuart and Barkly Highways is listed in Table 18-5. The nearest traffic count stations are:

- RAVDP010 being 100 kilometres south of Alice Springs (refer to Figures 18-1 and 18-2).
- RAVDC051 being about 100 kilometres from the community of Titjikala.

The turn off to the Henbury Access Road is approximately 140 kilometres south of Alice Springs. Total inbound and outbound AADT were 500 at this location. At the Maryvale count station, AADT total numbers for 2014 were considerable less (127).

Table 18-5 Baseline road traffic volumes along the Stuart and Barkly Highways

Count station	Route	Location	2013			2014		
			Total	In	Out	Total	In	Out
RTVDP001	Stuart Hwy	North of Threeways (100 metres)	410	219	191	411	213	198
RTVDC029	Barkly Hwy	Radio Repeater 8501	264	144	120	270	134	136
RTVDC004	Barkly Hwy	East of Stuart Hwy (10 kilometres)	254	130	124	247	121	126
RTVDP003	Stuart Hwy	South of Threeways (5 kilometres)	389	203	186	395	205	190
RTVDP002	Stuart Hwy	South of Tennant Creek (10 kilometres)	410	212	198	403	207	196
RAVDP014	Stuart Hwy	North of Tanami Hwy (1.5 kilometers)	590	299	291	608	312	296
RAVDP001	Stuart Hwy	North of Alice Springs (3 kilometres)	963	494	469	978	500	478
RAVDC073	Stuart Hwy	South of Airport Intersection (1 kilometers)	1,388	688	700	1,591	806	785
RAVDP010	Stuart Hwy	South of Alice Springs (100 kilometres)	503	252	251	500	254	246
RAVDP003	Stuart Hwy	North of Kulgera (200 metres)	304	168	136	313	172	141
RAVDC051	Maryvale Road	16 kilometres south of Santa Teresa Road	-	-	-	127	63	64

SOURCE: Annual Traffic Report 2015 Territory Asset Management Services

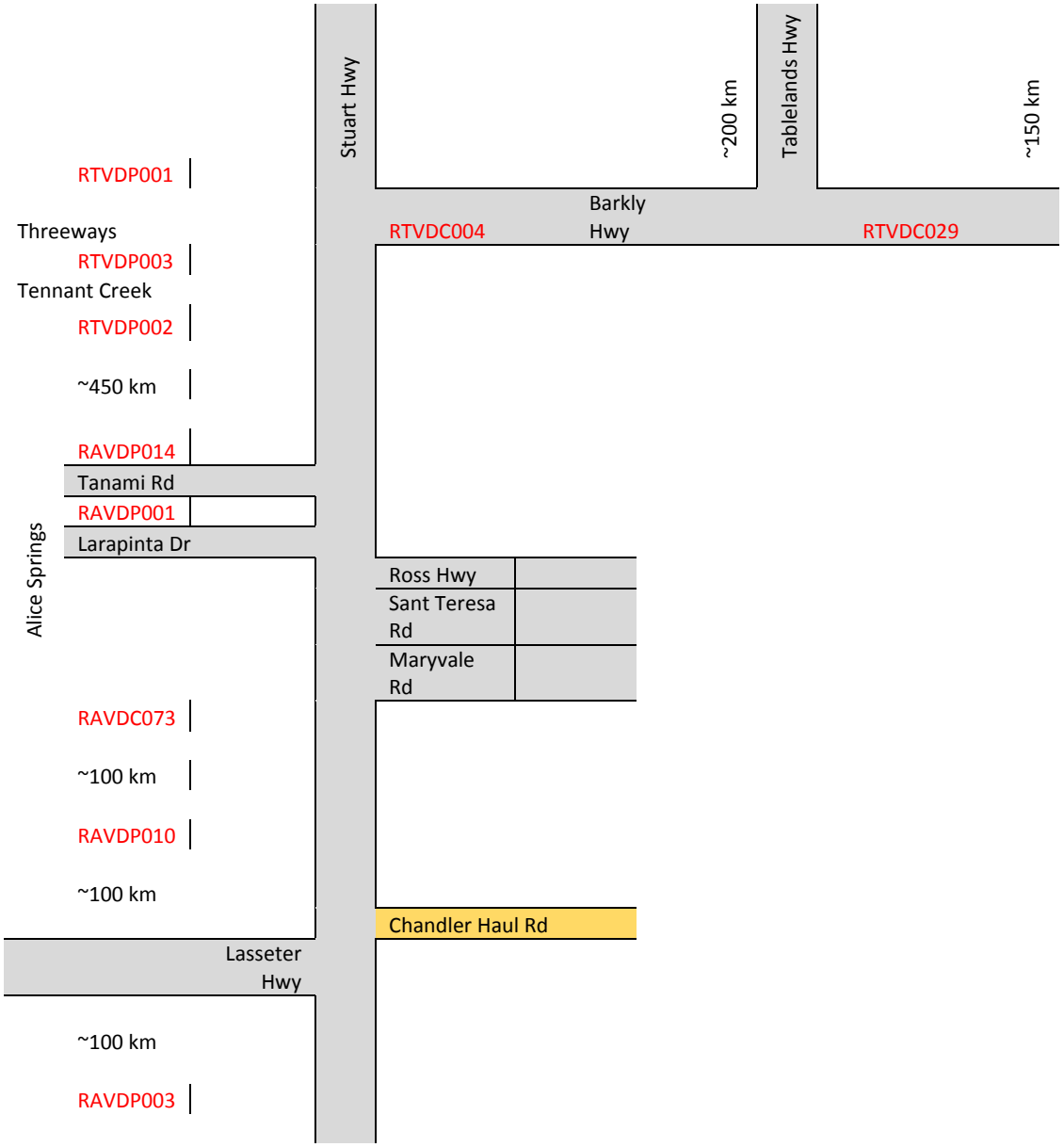


Figure 18-1 Schematic of traffic count data locations in relation to the Proposal

Darwin Port
Chandler Facility
Refer inset A
Port Adelaide
Arafura Sea
Gulf of Carpentaria
NORTHERN TERRITORY
AUSTRALIA
SIMPSON DESERT
CTORIA DESERT
SOUTH AUSTRALIA
Great Australian Bight
Adelaide
ALICE SPRINGS DARWIN RAILWAY
CENTRAL AUSTRALIAN RAILWAY
TRANS AUSTRALIAN RAILWAY
Inset A
TIETKENS VALE
HUGH RIVER
MALONEY CREEK
FINKE RIVER
CHANDLER RANGE
BACON RANGE
ERNEST GILES ROAD
HENBURY METEORITE CRATERS
STUART HIGHWAY
PALMER RIVER
SEYMOUR RANGE
MOUNT SUNDAY RANGE
ERLDUNDA RANGE
Alice Springs
DINGO GAS FIELD
PHILLIPSON STOCK ROUTE
HUGH RIVER STOCK ROUTE
OAK VALLEY
PWERTENTYE
HUGH RIVER
OLIFFE RANGE
GUMTREE HILLS
MARYVALE ROAD
CENTRAL AUSTRALIAN RAILWAY
CHAMBERS PILLAR ROAD
TITJIKALA
CHARLOTTE RANGE
MARYVALE HILLS
FINKE RIVER
HUGH HUGH RIVER
Adelaide
8 4 0 8 Kilometers
Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Document Path: Ti5 Operations\5 10 GIS\02 Chandler\Maps\Chandler_TransportRoutes.mxd

N
210 105 0 210 Kilometers
Coordinate System:
GCS GDA 1994

Legend
- ML30612
- Henbury Access Road
- Chandler Haul Road
- Access road to Titjikala
- Chandler Facility
- Apirnta Facility
- Accomodation village
- Proposed bore field

Figure 18-2
Road network in the vicinity of the Proposal

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use.
Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.
Data supplied by Department of Land Resource Management.
Copyright Northern Territory of Australia.

18.4.4 Assessment of risk during construction

This section discusses the increased road and rail traffic and the use of existing road and rail transportation networks during construction of the Proposal.

Road traffic and transportation

This section discusses the road traffic generated during the construction of the proposed Chandler Haul Road and Henbury Access Road. There would be minimal traffic and transportation impacts on the existing Maryvale Road, Chambers Pillar Road and the Stuart Highway during construction of the Proposal.

Maryvale Road

Site access in the initial months of construction would be via the existing Maryvale Road. Traffic volumes would be periodic due to the nature of the construction works. During peak construction periods, traffic volumes could be approximately five to 10 heavy vehicle movements per day (or one every hour on average) and 10 to 20 light vehicle movements per day (or two every hour on average).

Given the Maryvale Road already has regular *changing road surface conditions* (Territory Asset Management Services 2015), the predicted number of heavy and light vehicle numbers is not anticipated to lead to a significant deterioration of existing road surface conditions.

If approved, the Proposal may represent a significant beneficial opportunity to improve existing road surface conditions for the entire length of Maryvale Road. This could lead to significant beneficial opportunities to improve road safety for vehicle users in Titjikala and, for tourists travelling to and from Chambers Pillar Nature Reserve along Maryvale Road.

Chambers Pillar Road

Chambers Pillar Road would only be accessed for about 25 kilometres from Maryvale. The vehicle numbers during construction would be the same as Maryvale Road.

Works to a section of Chambers Pillar Road would be undertaken during construction to create a crossing where the proposed Chandler Haul Road meets Chambers Pillar Road. At the time of submitting the EIS, AADT data was not available for this section of road. However, after conducting four years of field work, average traffic numbers along Chambers Pillar are generally low (less than 100) and tend to peak in in the dry months (May to September and when the Finke Desert Race occurs). Impacts to Chambers Pillar Road are considered negligible.

Chandler Haul Road

As the initial site establishment works are progressed, construction access to the proposed Apirnta Facility would be developed along an existing access track (the alignment of the proposed Chandler Haul Road).

Traffic volumes would be periodic due to the nature of the construction works. During peak periods, traffic volumes could be between five to 10 heavy vehicle movements per day (on average) and five to 10 light vehicle movements per day (on average) during construction of the proposed Chandler Haul Road.

Henbury Access Road

As construction progresses, permanent access to the proposed Apirnta Facility would be developed along an existing access track that connects to the Stuart Highway (the alignment of the proposed Henbury Access Road). It is anticipated that construction of the Henbury Access Road would occur across two fronts, with one crew moving east from the Stuart Highway and a second crew moving west from the Apirnta Facility.

Traffic volumes would be periodic due to the nature of the construction works. During peak periods, traffic volumes could be between five to 10 heavy vehicle movements per day (on average) and 10 to 20 light vehicle movements per day (on average) during construction of the proposed Henbury Access Road.

Stuart Highway

The Stuart Highway would not be utilised for access during construction.

Rail traffic and transportation

No equipment or materials would be delivered to site via rail during construction of the Proposal. There would also be no need to rail closures during construction of the Proposal. Therefore, there would be no impact on the Central Australian Railway during construction of the Proposal.

18.4.5 Assessment of risk during operation

This section discusses the increased road and rail traffic and the use of existing road and rail transportation networks during operation of the Proposal.

Road traffic and transportation

This section discusses road traffic on the proposed Chandler Haul Road and Henbury Access Road during operation of the Proposal. There would be minimal traffic and transportation impacts on the existing Maryvale Road, Chambers Pillar Road and the Stuart Highway during operation of the Proposal.

Maryvale Road

Access via Maryvale Road would slowly be phased out during operation of the Proposal as the bulk of movements for waste deliveries would occur via rail and along the private Chandler Haul Road. There would be minimal increase in traffic volumes along Maryvale Road during operation of the Proposal.

Chambers Pillar Road

The main risks arising on Chambers Pillar Road would be vehicle collision at the intersection of the private Chandler Haul Road. Without adequate road safety measures in place, and an effective Operation Traffic Management Plan, the impact to humans is considered a high risk.

Chandler Haul Road

Once construction has been completed and commissioning and operational ramp up commences, the Chandler Haul Road would be used for the transfer of waste materials via truck from the Apirnta Facility to the Chandler Facility, and the backhaul of salt product from the Chandler Facility to the rail siding at the Apirnta Facility. Traffic volumes would likely be between 15 to 25 heavy vehicle movements and five to 10 light vehicle movements per day (on average) along the Chandler Haul Road.

Henbury Access Road

Once construction has been completed and commissioning and operational ramp up commences, long-term site access would move from Maryvale Road (used during construction) to the proposed Henbury Access Road from a new intersection with the Stuart Highway. The vast majority of waste deliveries and salt exports would be via rail, therefore, road traffic volumes would likely be low along the proposed Henbury Access Road. Traffic volumes would likely be between one to two heavy vehicle movements and two to five light vehicle movements per day (on average) along the proposed Henbury Access Road.

Stuart Highway

The Proposal assumes 90 % of all waste would be delivered to the proposed Apirnta Facility. This leaves 10 % to be delivered by road (the Stuart Highway). If this were to occur, this equates to approximately one truck per week.

Workers from Alice Springs would access the Stuart Highway to reach the proposed Henbury Access Road. The Stuart Highway is considered to have ample carrying capacity to adsorb drive-in-drive-out worker shifts per week.

Rail traffic and transportation

Based on the above average life of Proposal waste tonnage, the proponent anticipates 52 train movements per year.

18.4.6 Mitigation and monitoring

Mitigation and management measures proposed to reduce traffic impacts during construction, operation, and closure and rehabilitation of the Proposal are listed in Table 18-4. These measures would include the development of a Construction and Operation Traffic Management Plan in line

with Australian Standard 1742.3. Both plans would be incorporated into the Proposal's CEMP, OEMP and RCP for the Proposal.

Table 18-6 Mitigation and management measures (traffic and transportation)

ID	Outcome	Mitigation/management measure	Timing
T.1	Minimise traffic and transportation impacts and reduce risk of vehicle collision and human collision with vehicle	Prepare and implement a Construction Traffic Management Plan in consultation with the NT Department of Transport in accordance with Australian Standard 1742.3	Pre-construction
T.2	Minimise traffic and transportation impacts	Install appropriate speed and warning signage prior to and at the crossing of Chambers Pillar Road.	Construction
T.3	Prevention of accidents between trucks hauling waste and salt along the Chandler Haul Road.	Develop a collision avoidance system for the Chandler Haul Road. Include the provision of a visible and/or audible alarm system to confirm the presence of vehicles traveling along the proposed Chandler Haul Road. Alarm system would alert drivers of haul trucks when another truck is within 500 metres, requiring a reduction in speed.	Operation
T.4	Minimise traffic and transportation impacts	Restrict speed limits to no more 60km/hr on the proposed Chandler Haul Road and Henbury Access Road. Ensure vehicles reduce speed and come to a complete stop at the crossing of Chambers Pillar Road.	Construction, operation, closure and rehabilitation
T.5	Minimise traffic and transportation impacts	Commit to workplace programs regarding road safety.	Construction, operation, closure and rehabilitation
T.6	Access to surrounding properties maintained	Maintain access to surrounding properties for the duration of the Proposal.	Construction, operation, closure and rehabilitation
T.7	Minimise traffic and transportation impacts and reduce risk of vehicle collision and human collision with vehicle	Prepare and submit to the NT Department of Transport a Construction Traffic Management Plan in accordance with Australian Standard 1742.3	Pre-construction
T.8	Understanding traffic impacts following final detailed design	The proponent would prepare a Traffic Impact Statement and submit to the NT Department of Transport.	Pre-construction.

18.4.7 Conclusion

Road traffic generated during construction and operation was modelled across the life of the Proposal. The projected traffic movements discussed above for Maryvale Road, the Stuart Highway and at the intersection of Chambers Pillar Road would require a Traffic Impact Statement. The Proposal would not require a Traffic Impact Assessment. This is because the predicted number of vehicle movements falls between 10 and 100 trips in peak traffic periods as defined by *Austroads Guide to Traffic Management Part 12 – Traffic Impacts of Development* and referenced within the NT

Department of Transport *Development Guidelines for Northern Territory Government Controlled Roads.*

There would be minimal impact on the existing road network as there is enough capacity on existing roads (Maryvale Road, Stuart Highway) to accommodate the increased traffic generated during construction, operation, and closure and rehabilitation of the Proposal.

The existing Central Australian Railway network has enough capacity to accommodate the increase in rail movements during operation of the Proposal. There would also be no impact on the existing rail network during closure and rehabilitation of the Proposal.

Mitigation measures, including the preparation and implementation of a Construction and Operation Traffic Management Plan would be implemented to reduce potential impacts on road and rail traffic and transportation during construction, operation, and closure and rehabilitation of the Proposal. These measures would be incorporated into the CEMP, OEP and RCP for the Proposal.

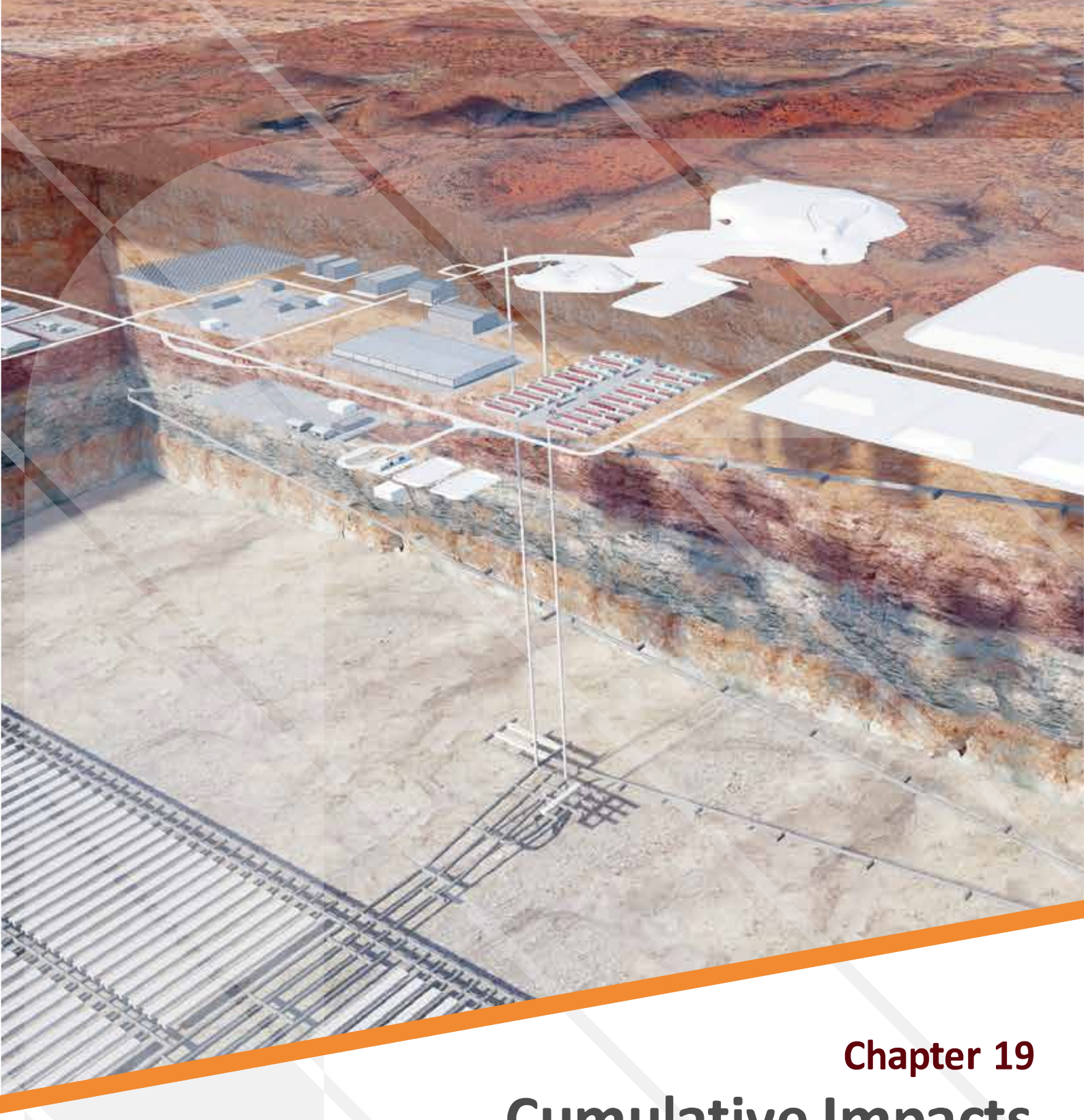
18.5 Environmental offsets

Assessments of significance for matters of national environmental significance have been prepared for six threatened fauna species and eight migratory bird species in accordance with the *Significant Impact Guidelines 1.1-Matters of National Environmental Significance* (DoE 2013). The assessments of significance are included in Appendix R and are summarised in Chapter 7.

At present, no biodiversity offsets are deemed necessary as there would be no significant impact to matters of national environmental significance during construction, operation, or closure and rehabilitation of the Proposal.

Additional surveys would be undertaken prior to construction to confirm the presence/absence of two matters of national environmental significance (threatened species) considered to have a low to moderate likelihood of occurrence within the proposed development footprint or vicinity. These are and Slater's skink (*Liopholis slateri slateri*) and the thick-billed grasswren (*Amytornis modestus indulkana*). Potential habitat for these species is located within the vicinity of the proposed Henbury Access Road.

If these species are found to be present, significant impacts would be avoided through changes to the proposed alignment of the Henbury Access Road. Alternatively, a program of trapping and relocating would be implemented to avoid significant impacts to these 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* (DSEWPaC 2012b) and in consultation with the DoEE.



Chapter 19

Cumulative Impacts

This page has been left intentionally blank

19 CUMULATIVE IMPACTS

19.1 Introduction

This chapter provides an assessment of the potential cumulative benefits and impacts that may arise as a result of the construction and operation of the Proposal with other projects planned in the region.

Cumulative benefits/impacts are incremental environmental benefits/impacts that are caused by past, present or reasonably foreseeable future activities that, when combined, may have a cumulative effect. When considered in isolation, the environmental benefits/impacts of any single project upon a receiver or resource may not be significant. However, the potential benefits/impacts may increase when individual effects are considered in combination, either within the same project or together with other projects.

19.2 Methodology

The assessment of cumulative benefits and impacts builds upon the detailed assessment of the environmental aspects presented in Chapter 7 through Chapter 18.

To identify the likelihood of cumulative impacts, potential construction and operational phase interfaces with other significant projects or initiatives were reviewed, specifically:

- Relevant projects under construction.
- Relevant projects that have publicly declared financial commitments.
- Relevant projects for which approval has been sought or that have been approved under relevant legislation.

In determining which other projects are relevant to the cumulative benefit and impacts assessment, the following criteria were taken in account:

- Location - the projects are located in proximity to the Proposal.
- Project timeframe - projects likely to be under construction concurrent with the Proposal or would otherwise have a noteworthy operational interaction with the Proposal.
- Project size - projects were listed on either local government websites or on the website of the NT EPA.

Consideration of cumulative benefits and impacts was inherently addressed as part of the detailed modelling approach for a number of environmental aspects assessed as part of specialist investigations presented in this EIS.

19.3 Relevant projects

There are a number of major projects in progress or proposed within 500 kilometres of Alice Springs. These projects are listed in Table 19-1 and their locations are shown in Figure 19-1.

Table 19-1 Major projects in progress or proposed in the vicinity of Alice Springs (including the Proposal)

Project (proponent)	Construction start date*	Operation start date*	Location	Construction employment (approx.)*	Operation employment (approx.)*
Tanami Gold Mine Expansion (Newmont)	2016	2017	Approximately 540 kilometres north-west of Alice Springs.	N/A	50
Mt Peake Project (TNG Limited)	2016	2018	Approximately 235 kilometres north of Alice Springs.	350	175-250
Jervois Mine (KGL Resources)	2017	2018	Approximately 270 kilometres north-east of Alice Springs.	360	300
Nolans Project (Arafura Resources)	2017	2019	Approximately 135 kilometres north-west of Alice Springs.	500	350
The Proposal	2017	2017	Approximately 120 kilometres of Alice Springs.	720 (peak)	150

**Information subject to change, refer to Appendix U*



Document Path: C:\GIS_SS\Maps\Chandler_CumulativeImpacts_SMA.mxd

N

50 25 0 50 Kilometers

Coordinate System:
GDA 1994 MGA Zone 53

Legend

Proposed development footprint

Figure 19-1
Major projects in progress or proposed
in the vicinity of Alice Springs (including the Proposal)

TELLUS

Tellus Holdings Ltd makes every effort to ensure this map is free of errors but does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use. Tellus Holdings Ltd provides this map without any warranty of any kind whatsoever, either expressor implied.

This document incorporates Data which is © Commonwealth of Australia (Geoscience Australia) 2006.

19.4 Cumulative benefits

There would be a significant benefit to the economy of the local region, the NT and to the economy of Australia as a result of the Proposal, as discussed in Chapter 12 and supported by Appendix U.

The capital expenditure is estimated to be around $676 million for the Proposal. The construction period would have a high local content - around 67% of all construction costs would be spent in Australia (36% spent in the NT). Over the construction period it is expected that 1,299 full time equivalent workers would be employed (all sourced from within Australia). Around 477 workers (or 37% of the construction workforce) would be sourced from the local region. In total, about 940 workers (or 72% of the construction workforce) would be sourced from the NT (including the local region) and the remaining 360 workers (or 28% of the construction workforce) would be sourced from the rest of Australia.

On average, there would be spending of just under $81 million per annum to operate the Proposal. Of this, 64% would be spent in Australia (a total of 52% would be spent in the NT, 32% of which would be spent in the local region). During steady state operations it is expected that 150 full time equivalent workers would be employed by the Proposal.

Just over 5,400 full time equivalent job years would be created over the life of the Proposal, an average of 217 full time equivalent job years per annum. The Proposal would deliver long term job creation in Australia, particularly in the NT where most of the job creation would be realised. An estimated 3,665 full time equivalent job years would be created in the NT over the life of the Proposal. This is equivalent to an average of 71 full time equivalent job years per annum.

Almost $3.4 billion would be contributed to the real incomes of Australians over the life of the Proposal. This includes an increase of $441 million to real incomes in the NT. The contribution to the local region would be higher at $476 million for the life of the Proposal.

Almost $1.9 billion in direct and indirect taxation would be paid over the life of the Proposal (or an average of around $75 million each year). The majority of this taxation would be in the form of company taxes paid by the proponent as well as other personal and company income taxes paid to the Federal Government. In total, the NT is likely to receive $34 million in payroll taxes as a result of direct and indirect state revenues from the Proposal, or an average of $1.4 million per annum.

The gross domestic product of Australia would rise by about $4.1 billion or an average of $166 million each year over the life of the Proposal. Most of this impact would be realised in the NT (the majority of which in the local region). About $3.6 billion (or an average of $144 million per year) would be added to the gross state product of the NT over the life of the Proposal.

These benefits, along with the economic benefits of the four major projects in progress or proposed in the general vicinity of Alice Springs would have a significant cumulative, beneficial effect on the economy of the local region, the NT and to the economy of Australia.

19.5 Cumulative impacts

Perpetual pastoral leases surround the Proposal. These include:

- Maryvale Station (approximately 3,244 square kilometres in size).
- Henbury Station (approximately 5,273 square kilometres in size).
- Idracowra Station (approximately 4,628 square kilometres in size).

The surrounding pastoral properties are well established, with a majority of the required infrastructure already established. There are no non-pastoral use applications or land clearing applications that have been recently approved within these perpetual pastoral leases. Therefore, cumulative impacts are expected to be negligible.

As discussed above, there are four projects in progress or proposed in the general vicinity of Alice Springs (refer to Table 19-1 and Figure 19-1). These projects have been identified because they are progressed in their development with construction expected to commence or progress in 2017. They are all located within 500 kilometres of Alice Springs and, therefore, there may be some social/economic cumulative impacts felt within the town. These impacts may include the recruitment of workers, the purchase of goods and services, or making use of infrastructure such as the airport, accommodation, training facilities and health facilities within Alice Springs.

There would be an overlap during both construction and operation of the four projects and the Proposal (refer to Table 19-1). Given the proximity of Alice Springs to the Proposal and the Nolans Project and the location of the town on the direct route to the Tanami Gold Mine, it is likely that all three proponents would be seeking to source some employees and goods and services from Alice Springs or to locate staff in the town.

Despite the possibility that a number of proposed projects may come on line at the same or similar times, the town of Alice Springs should be able to absorb an increase in demand from the additional developments. In terms of visitor accommodation, the current annual room vacancy rate of 65% and seasonally high vacancy rates of 80% suggest that there are approximately 500 rooms available for overnight accommodation in the town on average which suggests that the current accommodation market could service the demand from the developments assuming that the supply of rooms are of a standard being sought by the industry. A falling housing market in terms of median prices and rental values also indicates there is some flexibility in the market to absorb additional population.

There are currently around 340 people seeking work in the Alice Springs Local Government Area. This represents an unemployment rate of 1.7%. It is unknown as to what qualifications these job seekers hold or what their career aspirations might hold. However, it could mean that there are opportunities for local job seekers to become involved in the construction and operation of these developments and in the flow on jobs created by the developments. It is likely, however, that projects would seek fly-in-fly out workers for part of their workforces. For example, the Tanami Gold Mine currently employs only fly-in-fly out staff and Arafura expects that around 210 of its steady state workers will be employed on a fly-in-fly out basis with just under 40 employees sourced from the surrounding region. The Proposal is expected to employ 477 people from the local region, which

includes Alice Springs, over the four years of construction and around 50 per year in operation. This could mean that the already tight labour market in the area would experience greater pressure which could lead to additional people moving to the town to take up job opportunities offered by the Proposal and others.

In the local region, $118 million would be spent during the four years of construction of which nearly $73 million would be spent in 2018, the peak construction year. An average of $26 million per annum would also be spent in the local region during operation (with the majority of that expenditure expected to be spent in Alice Springs). This may result in pressure on local businesses during the peak construction period if all projects proceed as planned and all have a similar local content. This increase in demand may also attract new businesses to Alice Springs, particularly given the number of proposed developments.

There would be no other cumulative impacts associated with the four identified projects and the Proposal. This is because the closest project is located over 250 kilometres from the Proposal (refer to Table 19-1 and Figure 19-1). As such, there would be no cumulative impact on biodiversity (including matters of national environmental significance), groundwater, surface water, heritage, or human health and safety. In addition, there would be no cumulative impacts associated with air quality, noise and vibration, or landscape and visual.

19.6 Conclusion

There would be significant economic benefits of the Proposal. About 270 workers would be employed per annum during construction and up to 180 full time equivalent workers would be employed during operation (around 90 would be sourced from the local region). Just over 5,400 full time equivalent job years would be created over the life of the Proposal, an average of 217 full time equivalent job years per annum. An estimated 3,665 full time equivalent job years would be created in the NT over the life of the Proposal. This is equivalent to an average of 71 full time equivalent job years per annum.

The capital expenditure is estimated to be around $676 million for the Proposal. Around 67 % of all construction costs would be spent in Australia (36 % spent in the NT). On average, there would be spending of just under $81 million per annum to operate the Proposal. Of this, 64% would be spent in Australia (a total of 52% would be spent in the NT).

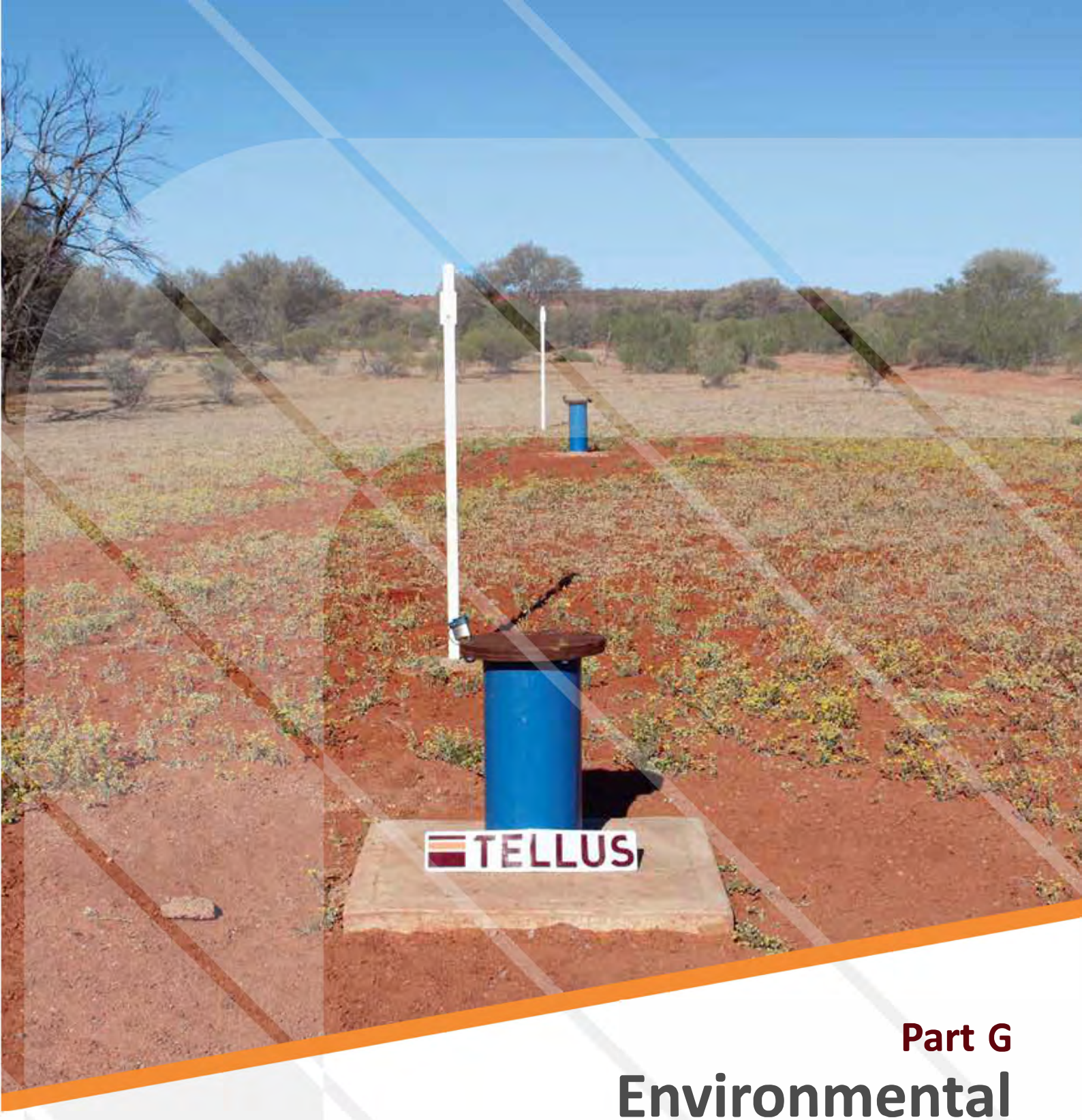
These benefits, along with the economic benefits of the four major projects in progress or proposed in the general vicinity of Alice Springs would have a significant cumulative, beneficial effect on the economy of the local region, the NT and to the economy of Australia.

Perpetual pastoral leases surround the Proposal. These properties are well established, with a majority of the required infrastructure already established. There are no non-pastoral use applications or land clearing applications that have been recently approved within these perpetual pastoral leases. Therefore, cumulative impacts are expected to be negligible.

There are four major projects in progress or proposed within 500 kilometres of Alice Springs. All have similar construction and operational start dates. Therefore, there may be some

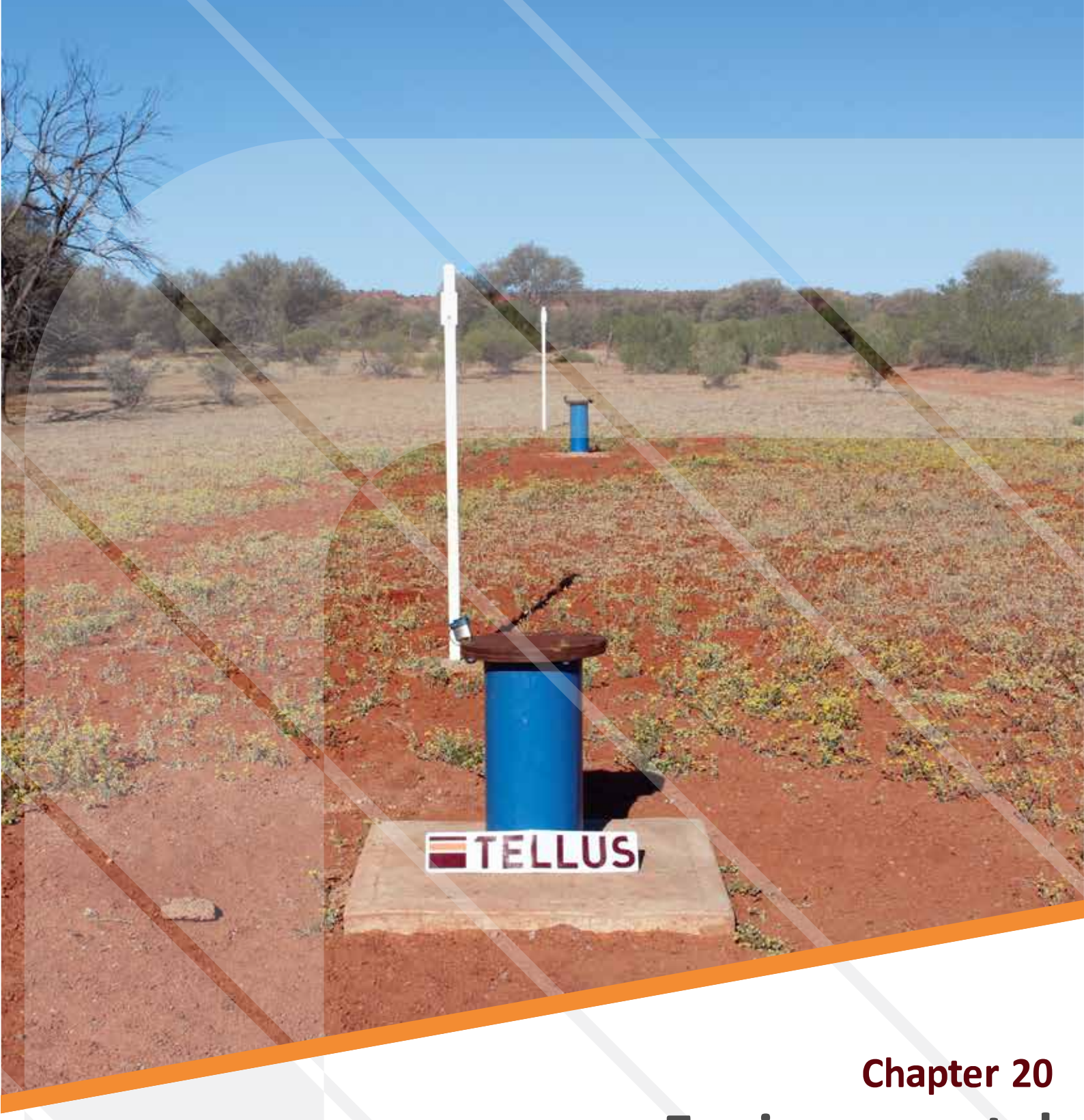
social/economic cumulative impacts felt within the town. These impacts may include the recruitment of workers, the purchase of goods and services, or making use of infrastructure such as the airport, accommodation, training facilities and health facilities within Alice Springs. Despite the possibility that a number of proposed projects may come on line at the same or similar times, the town of Alice Springs should be able to absorb an increase in demand from the additional developments.

There would be no other cumulative impacts associated with the four identified projects and the Proposal. This is because the closest project is located over 250 kilometres from the Proposal. As such, there would be no cumulative impact on biodiversity (including matters of national environmental significance), groundwater, surface water, heritage, or human health and safety. In addition, there would be no cumulative impacts associated with air quality, noise and vibration, or landscape and visual.



Part G

Environmental Management



Chapter 20

Environmental Mangement

This page has been left intentionally blank

20 ENVIRONMENTAL MANAGEMENT

20.1 Overview

The environmental assessment has indicated that the Proposal would result in environmental impacts during construction, operation, and closure and rehabilitation. A range of management plans, protocols and procedures to manage the environmental impacts of the Proposal would be implemented. Specifically, a CEMP, OEMP and RCP would be prepared and implemented for the Proposal. The CEMP, OEMP and RCP are discussed in Section 0.0. Mitigation measures to minimise the impact of the Proposal are listed in Table 20-1.

Environmental management plans and monitoring

A CEMP, OEMP and RCP would be prepared and implemented for the Proposal. The plans would include:

- Environmental objectives and performance targets for construction and operation.
- 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 environmental assessment.
    - Relevant construction 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 environmental assessment 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, including (but not limited to):
    - Mine Management Plan.
    - Biodiversity Management Plan.
    - Bushfire Management Plan.

- Water Management Plan.
- Sediment and Erosion Management Plan.
- Cultural Heritage Management Plan.
- Safety Case.
- Air Quality Management Plan.
- Noise and Vibration Management Plan.
- Social Impact Management Plan.
- Rehabilitation and Closure Plan.
- Biting Insect Management Plan.
- Traffic Management Plan.

- Incident response procedure.
- Monitoring and auditing program.

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 would continue through closure and rehabilitation of the Proposal. Monitoring requirements would be listed within the CEMP, OEMP and RCP.

20.2 Summary of mitigation measures that would be implemented for the Proposal

Mitigation measures to minimise the effects of the Proposal are presented in Table 20-1. These measures would be implemented prior to and during construction, operation, and/or closure and rehabilitation of the Proposal. They would be incorporated into the CEMP, OEMP and/or RCP, as appropriate

Table 20-1 Collation of mitigation and management measures for the Proposal

ID	Outcome	Mitigation/management measure	Timing
Biodiversity			
B.1	Preservation of biodiversity.	Finalise draft Biodiversity Management Plan prior to construction and incorporate into the CEMP, OEMP and/or RCP for the Proposal. The plan collates measures to mitigate and manage potential impacts on biodiversity.	Pre-construction
B.2	Reduced incidence of bushfire.	Finalise draft Bushfire Management Plan prior to construction and incorporate into the CEMP, OEMP and RCP. The plan collates measures to mitigate and manage potential impacts on biodiversity.	Pre-construction
B.3	Preservation of biodiversity.	Provide workers with an environmental induction prior to starting construction activities. This would include information on the ecological values of the site and protection measures to be implemented to protect biodiversity during construction.	Pre-construction and construction
B.4	Protection of threatened species.	Undertake pre-clearance surveys for threatened species by a qualified ecologist.	Pre-construction and construction
B.5	Minimisation of vegetation removal and habitat loss.	Defer vegetation removal until necessary.	Pre-construction and construction
B.6	Minimisation of vegetation removal and habitat loss.	Locate site offices and stockpiles in already cleared and disturbed areas, where possible.	Pre-construction and construction
B.7	Minimisation of vegetation removal and habitat loss.	Provide maps to construction staff clearly showing vegetation clearing boundaries.	Pre-construction and construction
B.8	Minimisation of vegetation removal and habitat loss.	Leave mature trees, where possible, especially desert oaks, bloodwoods and bush tucker species.	Construction
B.9	Minimisation of vegetation removal and habitat loss.	Leave fallen logs greater than 15 cm diameter or relocate to surrounding environment.	Construction
B.10	Minimise vegetation removal and habitat loss.	Relocate bird nests found in trees or shrubs to be cleared to surrounding environment.	Construction
B.11	Reduced incidence of fauna injury/mortality.	Ensure fauna is removed from areas intended to be cleared by a qualified ecologist.	Pre-construction and construction
B.12	Reduced incidence of fauna injury/mortality.	Avoid driving during high risk times; dawn, dusk and at night, where possible.	Construction, operation, closure and rehabilitation

ID	Outcome	Mitigation/management measure	Timing
B.13	Reduced incidence of fauna injury/mortality.	Prohibit off-road driving.	Construction, operation, closure and rehabilitation
B.14	Reduced incidence of fauna injury/mortality.	Develop and maintain a fauna strike register.	Construction, operation, closure and rehabilitation
B.15	Reduced incidence of fauna injury/mortality.	Limit access of third parties on-site.	Construction, operation, closure and rehabilitation
B.16	Reduced incidence of fauna injury/mortality.	Ensure traffic adheres to speed limits and local road rules.	Construction, operation, closure and rehabilitation
B.17	Reduced incidence of fauna injury/mortality.	Ensure speed limit and potential fauna crossing signs clearly are displayed on Chandler Haul Road, Henbury Access Road and other access tracks, as necessary.	Construction, operation, closure and rehabilitation
B.18	Reduced habitat fragmentation and edge effects.	Implement weed and invasive species mitigation measures listed above.	Construction, operation, closure and rehabilitation
B.19	Reduced habitat fragmentation and edge effects.	Implement introduced fauna mitigation measures listed above.	Construction, operation, closure and rehabilitation
B.20	Reduced habitat fragmentation and edge effects.	Undertake routine inspections for weeds and invasive species.	Construction, operation, closure and rehabilitation
B.21	Elimination of waste left uncontained on-site.	Develop and implement a Waste Management Plan.	Pre-construction
B.22	Elimination of waste left uncontained on-site.	Ensure domestic waste stored in fauna proof bins.	Construction, operation, closure and rehabilitation
B.23	Elimination of waste left uncontained on-site.	Ensure waste stored is stored in appropriately labelled containers.	Construction, operation, closure and rehabilitation
B.24	Elimination of waste left uncontained on-site.	Bund liquid waste, where required.	Construction, operation, closure and rehabilitation
B.25	Elimination of waste left uncontained on-site.	Implement waste hierarchy of avoid/minimise, reuse, recycle, recovery, and then disposal.	Construction, operation, closure and rehabilitation
B.26	Elimination of waste left uncontained on-site.	Ensure waste is disposed off-site by licensed contractor(s).	Construction, operation, closure and rehabilitation
B.27	Elimination of waste left uncontained on-site.	Ensure hazardous waste and hydrocarbons are stored separately in bunding, with appropriate signage.	Construction, operation, closure and rehabilitation
B.28	Minimised dust.	Stage vegetation removal (clearing) to reduce total exposed cleared surface at any one time.	Construction
B.29	Minimised dust.	Avoid clearing during dry windy conditions.	Construction

ID	Outcome	Mitigation/management measure	Timing
B.30	Minimised dust.	Clear with blade up, where possible.	Construction
B.31	Minimised dust.	Leave vegetation 10 centimetres in height on firebreaks and non-crucial tracks.	Construction
B.32	Minimised dust.	Use water trucks during construction and closure and rehabilitation to control dust.	Construction, closure and rehabilitation
B.33	Elimination of unnecessary lighting in surrounding environment.	Use lower intensity lights, e.g. yellow or red lighting, where possible. This would reduce impacts on nocturnal species and limit insect attraction.	Construction
B.34	Elimination of unnecessary lighting in surrounding environment.	Only have minimal lights on needed for safe operation of facilities.	Operation
B.35	Elimination of unnecessary lighting in surrounding environment.	Direct lights towards the ground (where possible) or use shields to direct lights to only where light is required. Have lights positioned as low as possible.	Construction, operation, closure and rehabilitation
B.36	Elimination of unnecessary lighting in surrounding environment.	Turn lights off when not in use.	Construction, operation, closure and rehabilitation
B.37	Elimination of unnecessary lighting in surrounding environment.	Restrict work to daylight hours, where possible.	Construction, operation, closure and rehabilitation
B.38	Reduce noise and vibration.	Turn off machinery when not in use.	Construction, operation, closure and rehabilitation
B.39	Reduce noise and vibration.	Maintain and regularly service all generators, engines and vehicles on-site.	Construction, operation, closure and rehabilitation
B.40	Reduce noise and vibration.	Ensure vehicles carry full loads were possible to limit the number of vehicles on the Chandler Haul Road and Henbury Access Road.	Construction, operation, closure and rehabilitation
B.41	Prevention of the introduction and spread of weeds and invasive species.	Vehicle/machinery wash-down prior to leaving Alice Springs or entering an area uncontaminated by weeds.	Construction, operation, closure and rehabilitation
B.42	Prevention of the introduction and spread of weeds and invasive species.	Avoid contact with weed or invasive species seed, plant matter or soil potentially contaminated with weed seeds.	Construction, operation, closure and rehabilitation
B.43	Prevention of the introduction and spread of weeds and invasive species.	Avoid clearing or removal of any weed or invasive species during seeding, or put plastic bag over seed heads before removing plant.	Construction, operation, closure and rehabilitation
B.44	Prevention of the introduction and spread of weeds and invasive species.	Remove seed and mud from vehicle tyres and front grill daily.	Construction, operation, closure and rehabilitation
B.45	Prevention of the introduction and spread of weeds and invasive species.	Undertake annual weed mapping in the vicinity of the proposed development footprint.	Construction, operation, closure and rehabilitation

ID	Outcome	Mitigation/management measure	Timing
B.46	Prevention of the introduction and spread of weeds and invasive species.	Remove weeds following specialist advice from qualified ecologist or Weeds Branch, NT Government.	Construction, operation, closure and rehabilitation
B.47	Prevention of the introduction and spread of weeds and invasive species.	Remove weed or invasive species before seeding times, where possible.	Construction, operation, closure and rehabilitation
B.48	Prevention of the introduction and spread of weeds and invasive species.	Avoid driving in wet and muddy conditions, where possible.	Construction, operation, closure and rehabilitation
B.49	Prevention of an increase in the number or frequency of introduced fauna.	Prevent access to artificial water and heat sources through construction of fences.	Construction, operation, closure and rehabilitation
B.50	Prevention of an increase in the number or frequency of introduced fauna.	Dispose of all waste in predator-proof bins.	Construction, operation, closure and rehabilitation
B.51	Prevention of an increase in the number or frequency of introduced fauna.	Develop and implement a no tolerance policy to the introduction of pest species by contractors, suppliers and personnel.	Construction, operation, closure and rehabilitation
B.52	Prevention of an increase in the number or frequency of introduced fauna.	Place brush or vegetation stockpiles across linear developments no longer required (access tracks etc.) to inhibit movement of predators and introduced herbivores.	Construction, operation, closure and rehabilitation
B.53	Prevention of an increase in the number or frequency of introduced fauna.	Undertake annual flora and fauna survey to record numbers of introduced fauna species.	Construction, operation, closure and rehabilitation
B.54	Prevention of an increase in the number or frequency of introduced fauna.	Develop, implement and maintain fauna sighting register.	Construction, operation, closure and rehabilitation
B.55	Prevention of an increase in the number or frequency of introduced fauna.	Develop and implement an introduced fauna control program.	Construction, operation, closure and rehabilitation
B.56	Prevention of an increase in the number or frequency of introduced fauna.	Carry out feral animal control as required in consultation with stakeholders.	Construction, operation, closure and rehabilitation
B.57	Prevention of an increase in the number or frequency of introduced fauna.	Install fauna proof fence around all infrastructure.	Construction
B.58	Prevention of an increase in the number or frequency of introduced fauna.	Reduce artificial standing water.	Construction, operation, closure and rehabilitation
B.59	Prevention of an increase in the number or frequency of introduced fauna.	Close off and rehabilitate any cleared areas no longer required for safe operation.	Construction, operation, closure and rehabilitation
B.60	Prevention of an increase in the number or frequency of introduced fauna.	Ensure waste receptacles are fauna proof.	Construction, operation, closure and rehabilitation
B.61	Prevention of an increase in the number or frequency of introduced fauna.	Do not feed fauna.	Construction, operation, closure and rehabilitation

ID	Outcome	Mitigation/management measure	Timing
B.62	Prevention of an increase in the number or frequency of introduced fauna.	Remove any dead fauna or insects and either dispose off-site or bury greater than 50 centimetres deep to avoid predators uncovering.	Construction, operation, closure and rehabilitation
B.63	Prevention of an increase in the number or frequency of introduced fauna.	Trap and relocate predator species if they are noticed to have increased in numbers and habituate around facilities. Trapping and relocating of fauna would be undertaken by a qualified ecologist.	Construction, operation, closure and rehabilitation
B.64	Prevention of fires resulting from the Proposal.	Keep up to date with bushfire website and state services.	Construction, operation, closure and rehabilitation
B.65	Prevention of fires resulting from the Proposal.	Construct and maintain firebreaks around infrastructure and significant habitats.	Construction, operation, closure and rehabilitation
B.66	Prevention of fires resulting from the Proposal.	No open flames outside of designated areas unless hot works permit is approved.	Construction, operation, closure and rehabilitation
B.67	Prevention of fires resulting from the Proposal.	Ensure flammable material is clearly labelled.	Construction, operation, closure and rehabilitation
B.68	Prevention of fires resulting from the Proposal.	Ensure adequate firefighting equipment is stored on-site and staff trained in use.	Construction, operation, closure and rehabilitation
B.69	Prevention of fires resulting from the Proposal.	Provide designated smoking area.	Construction, operation, closure and rehabilitation
B.70	Prevention of fires resulting from the Proposal.	Organise and implement strategic back burning with traditional owners and Central Land Council.	Construction, operation, closure and rehabilitation
B.71	Prevention of fires resulting from the Proposal.	Implement and carry out annual fuel load surveys before high risk fire season.	Construction, operation, closure and rehabilitation
B.72	Prevention of impacts to surrounding flora or watercourses from salt.	Survey/monitor flora in dominant down wind direction from salt stockpiles for impacts.	Construction, operation, closure and rehabilitation
B.73	Prevention of impacts to surrounding flora or watercourses from salt.	Cover all salt during transport.	Construction, operation, closure and rehabilitation
B.74	Prevention of impacts to surrounding flora or watercourses from salt.	Monitor dust and airborne particles.	Construction, operation, closure and rehabilitation
B.75	Prevention of impacts to surrounding flora or watercourses from salt.	Store salt in open stockpile for minimum time required.	Construction, operation, closure and rehabilitation
B.76	Prevention of unauthorised third party access.	Inspect site for signs of unauthorised entry.	Construction, operation, closure and rehabilitation

ID	Outcome	Mitigation/management measure	Timing
B.77	Prevention of unauthorised third party access.	Record all access to site in a site register.	Construction, operation, closure and rehabilitation
B.78	Prevention of unauthorised third party access.	Ensure visitors complete induction or are accompanied by Tellus employee whilst on-site.	Construction, operation, closure and rehabilitation
B.79	Prevention of unauthorised third party access.	Dog leg smaller access tracks when joining larger roads to limit third party access by reducing access tracks visibility from the main road.	Construction
B.80	Prevention of unauthorised third party access.	Mark access tracks and roads as private property.	Construction
B.81	Prevention of unauthorised third party access.	Erect clear signage indicating prohibition of unauthorised entry.	Construction
B.82	Prevention of soil compaction and topsoil loss.	Locate roads, access tracks and required operational areas on solid surfaces, where possible.	Construction
B.83	Prevention of soil compaction and topsoil loss.	Limit compacted areas to minimum required.	Construction
B.84	Successful rehabilitation of disturbed areas.	Develop and implement a closure and Rehabilitation Management Plan.	Pre-closure and rehabilitation
B.85	Successful rehabilitation of disturbed areas.	Install erosion and sediment control temporary structures to assist with rehabilitation.	Closure and rehabilitation
B.86	Successful rehabilitation of disturbed areas.	Respread spoil first, then top soil and last cleared vegetation over surfaces.	Closure and rehabilitation
B.87	Successful rehabilitation of disturbed areas.	Leave any infrastructure, plant or cleared area as so detailed in a land use agreement with the land manager.	Closure and rehabilitation
B.88	Successful rehabilitation of disturbed areas.	Remove all infrastructure, plant, machinery and operational and construction wastes.	Closure and rehabilitation
B.89	Successful rehabilitation of disturbed areas.	Re-contour all cleared surfaces to match surrounding topography, as close as possible.	Closure and rehabilitation
B.90	Successful rehabilitation of disturbed areas.	Rip any compacted areas.	Closure and rehabilitation
B.91	Successful rehabilitation of disturbed areas.	Ensure final surface is rough to increase infiltration.	Closure and rehabilitation
B.92	Successful rehabilitation of disturbed areas.	Block all access points to roads and tracks, unless agreed with land manager.	Closure and rehabilitation

ID	Outcome	Mitigation/management measure	Timing
B.93	Successful rehabilitation of disturbed areas.	Fill in sumps or turkey nest, unless agreed otherwise with land manager.	Closure and rehabilitation
B.94	Successful rehabilitation of disturbed areas.	Close off and seal all groundwater wells.	Closure and rehabilitation
B.95	Successful rehabilitation of disturbed areas.	Re-spread top soil.	Closure and rehabilitation
Groundwater			
GW.1	Sustainable use of groundwater reserves.	Apply for water abstraction licences and permits under the Water Act.	Pre-construction
GW.2	Avoid groundwater contamination.	Grout and seal production bores during construction, operation and post closure (as indicated in Sections 8.1.1 and 8.1.2).	Pre-construction
GW.3	Monitor and record groundwater drawdown.	Ensure localised depressurisation of groundwater systems are monitored with data loggers in monitoring bores to ascertain potential of the Proposal to impact local groundwater users. Ensure groundwater level data is reviewed and reported in an Annual Environmental Monitoring Report (AEMR).	Pre-construction, construction, operations, post-closure
GW.4	Develop of detailed groundwater quality database.	Report groundwater quality results to the DPIR and the NT EPA every four months (April, August and December) to compare seasonal data against project activities.	Seasonal (on a rolling basis over the life of the mine).
GW.5	Consultation to develop a local groundwater database.	Undertake a hydro-census (condition) survey of local groundwater users prior to construction to ascertain bore condition and current status of the bores located within a 25 kilometre spatial buffer around the proposed Chandler Facility. Involve consultation with local groundwater users, with an end purpose of establishing baseline conditions of existing local groundwater users.	Pre-construction
GW.6	Develop a detailed groundwater database.	Construct four additional water monitoring sites (as nested sites) to observe shallow groundwater and to monitor deeper systems predicted to be intercepted through mining activities. Monitor groundwater levels and quality near Titjikala, the Finke River, and within the deeper groundwater systems (Stairway Sandstone and Jay Creek Formations) near the proposed mine portal. Undertake shallow monitoring of ephemeral groundwater in aeolian/alluvial sediments at the Chandler Facility and Apirnta Facility to monitor any pollutant losses into the sub-surface.	Pre-construction

ID	Outcome	Mitigation/management measure	Timing
GW.7	Develop a detailed groundwater database.	Complete a groundwater isotope study for monitoring bores prior to construction to confirm the relationship between shallow and deeper groundwater systems, and to confirm the origin and residence time of groundwater.	Pre-construction
GW.8	Develop a detailed groundwater database.	Despite there being no known groundwater dependent ecosystems in the immediate vicinity of the Proposal, potential groundwater dependent ecosystems should be monitored and modelled through detailed design if identified to be potentially impacted by the Proposal. Establish a monitoring program if potential groundwater dependent ecosystems are identified to be impacted through the construction, operation or closure and rehabilitation of the Proposal.	Pre-construction (detailed design)
GW.9	Avoid groundwater contamination.	Ensure that the management of groundwater and surface water inflow into the mine portal and ventilation shafts, including the design and capture of this water is undertaken in consultation with the DPIR who administer the Mine Management Plan.	Construction
GW.10	Sustainable use of groundwater reserves.	Ensure preference is given to re-use groundwater inflows over potable water for construction activities, where reasonable and feasible.	Construction
GW.11	Develop a more detailed understanding of local groundwater network.	Refine or further develop the groundwater model to verify the predictions within the EIS (if water level variations outside of the natural range are observed). Ensure modelling is consistent with established guidelines, which allow for analytical or numerical modelling if appropriate for the project context and risks, subject to discussion and agreement with government agencies.	Operations
GW.12	Develop a detailed groundwater database.	Monitor groundwater abstraction in production bores. Fit a cumulative flow meter to each production bore, and install pressure transducers in each bore to monitor groundwater drawdown at source.	Construction, operations, post-closure
Surface water			
SW.1	Management of floodwater draining towards the Chandler Facility from the Maryvale Hills upstream of the mine site.	Formalise drainage channels through or around the site so that upstream runoff does not cause flooding of the site, and so that it is not contaminated by site runoff or sedimentation. Raise flood prone site infrastructure above surrounding ground level.	Pre-construction

ID	Outcome	Mitigation/management measure	Timing
SW.2	Improved water quality and attenuation of surface water flow.	Treat runoff to improve water quality resulting in an attenuation of flows, mitigating any increase in runoff peak flows or volumes.	Pre-construction
SW.3	Movement or reconfiguration of Halfway Dam.	Investigate current and future use of the Halfway Dam. Develop proposals to move or reconfigure the dam and intake.	Pre-construction
SW.4	Management of floodwater on Chandler Haul Road.	Manage floodwater by: • Raising the road above surrounding ground level to prevent flooding. • Installing culverts to pass flood flow and reduce/minimise upstream ponding. • Installing causeways over which floodwaters in excess of the design event can pass, but that raise the road above frequent flood levels. Carrying out repairs, following flood events, as necessary.	Pre-construction
SW.5	Minimisation of impacts from the Henbury Access Road at the Finke River crossing.	Limit the engineering required to cross the river.	Construction
SW.6	No long term alterations to local hydrology.	Allow natural surface drainage to continue without interruption, where possible.	Construction
SW.7	No long term alterations to local hydrology.	Avoid clearing or disturbance to watercourses or drainage depressions, where possible.	Construction
SW.8	No long term alterations to local hydrology.	Avoid infrastructure developments in any watercourse or drainage depressions, where possible.	Construction
SW.9	No long term alterations to local hydrology.	Ensure no impedance to natural creek flow, where possible.	Construction
SW.10	No long term alterations to local hydrology.	Develop creek crossings to natural contours of creek bed.	Construction
SW.11	No long term alterations to local hydrology.	Remove any concentrations points that would impede natural sheet flow.	Construction
SW.12	No long term alterations to local hydrology.	Ensure minimal disturbance within watercourse buffer zones.	Construction
SW.13	No long term alterations to local hydrology.	Leave large mature trees and shrubs, where possible.	Construction
SW.14	No long term alterations to local hydrology.	Conduct routine inspection and maintenance of drains and watercourses.	Construction, operation, closure and rehabilitation

ID	Outcome	Mitigation/management measure	Timing
SW.15	Avoidance of spills or accidental loss of hazardous materials.	Store hazardous waste within a bunded area sufficient to hold 110% of all material.	Construction, operation, closure and rehabilitation
SW.16	Additional monitoring.	Undertake level/flow measurements on Halfway Dam catchment and three to four catchments draining to the Chandler Haul Road or Chandler Facility, and including the catchment draining through the Apirnta Facility.	Pre-construction; construction, closure and rehabilitation.
SW.17	Additional investigations during detailed design.	Develop stormwater models of the Chandler Facility and Apirnta Facility, including the management of site runoff and the diversion /conveyance of floodwaters from upstream catchments around the sites.	Pre-construction
SW.18	Additional investigations during detailed design.	Develop two-dimensional modelling of flow paths and inundation in the mine lease area, including the 'washout area' to better understand the potential for floodwaters to reach the Hugh River near Titjikala. This investigation would include an assessment of infiltration and evaporation.	Pre-construction
SW.19	Additional investigations during detailed design.	Model flood risk and scour protection at the crossing of the Finke River.	Pre-construction
SW.20	Additional investigations during detailed design.	Model flood risk[33] of haul crossings (bridges, culverts, causeways) of drainage lines.	Pre-construction
SW.21	Develop site specific water quality guidelines.	Develop guidelines for both the no-flow and flowing phases. This could be done by collecting and interrogating monitoring data and developing conceptual, probabilistic and/or numerical models that incorporate flow, catchment and in-stream influences. This site-specific system would be developed during detailed design and as part of the Water Management Plan and relies on obtaining more site data.	Pre-construction
SW.22	No offsite sedimentation.	Improving water retention by slowing upstream surface flow and improving transmission properties, which provides more time for water to infiltrate.	Pre-construction and Construction

[33] *The modelling would include an expanded suite of design events, including extreme events such as the Probable Maximum Flood*

ID	Outcome	Mitigation/management measure	Timing
SW.23	Preventing erosion and sedimentation.	Decreasing runoff rate and its velocity by providing appropriate surface drainage systems for safe conduct of water into pre-designed surface storage systems.	Pre-construction
SW.24	No offsite pollution.	Silty or oily water should not be used for dust suppression purposes, because this would transfer pollutants to the haul roads or generate more dust.	Construction and operation
SW.25	No offsite release of salt laden sediment.	A clay lined drainage swale would be constructed around the perimeter of the run of mine salt stock pile to prevent offsite release of salt laden sediment.	Operation
SW.26	Prevent sediment from being tracked off site and onto the road.	It is recommended that one entry / exit point to the Apirnta Facility and Chandler Facility sites should be established. If the site slopes towards this entry / exit, drainage and sediment control devices should be installed so that all sediment laden runoff can be fully contained and treated on-site.	Pre-construction
SW.27	Prevent sediment from being tracked off site and onto the road.	Vehicles and construction equipment may require washing to prevent transfer and accumulation of mud on the haulage and access roads. Alternatively, manned jet washes or lance sprays could be used in a bunded area where the runoff can be contained and channelled to a treatment area, such as a settlement pond.	Construction and operation
SW.28	Best practice in stockpile management.	Soil and sand stockpiles need to be located within the compound and upslope of a sediment control. Impervious covers, filter fences, mulch berms or sediment fences.	Construction and operation
SW.29	Prevent sediment runoff.	Provision of a sediment trap, such as a mulch bank or a sediment fence, on the downslope boundaries of the Apirnta Facility, Chandler Facility and haulage roads is recommended. The mulch banks and sediment fencing should be positioned on the contour where possible.	Construction and operation and closure
SW.30	Prevent sediment runoff.	Onsite drop inlet pits and haulage road side entry pits should be protected prior to the commencement of works or as soon as constructed.	Construction and operation and closure
SW.31	Prevent sediment runoff.	Buffer strips and vegetation filters should be employed, where practical, along the haulage road instead of sediment trapping structures (DLRM, 2013b).	Construction and operation and closure
SW.32	Best possible location for the replacement of Halfway Dam.	Make use of a similar gully or depression off-line from an adjacent to a creek with similar catchment area nearby on gently sloping	Detailed design

ID	Outcome	Mitigation/management measure	Timing
		terrain (<15%). A site investigation and selection should be undertaken to optimise the sustainable use of available water within a dam's catchment. The size of the catchment, soil and vegetation characteristics and path of surface run-off water determines what water is available within a catchment. Contour maps should be used to predict the path of rainfall and irrigation run-off within the dam's catchment.	
SW.33	Prevent the release of stormwater offsite.	Stormwater from disturbed areas would not be discharged into down-gradient properties. To capture 'dirty' surface runoff, u-shaped earth banks would be constructed to pond water (DLRM, 2013b).	Detailed design and pre-construction
SW.34	Provide habitat and prevent erosion.	Retained vegetation can have the dual purpose of not only assisting in the settling of sediment from overland flows, but also provide a refuge for flora and fauna.	Construction and operation.
SW.35	Prevent erosion and sedimentation.	A disturbance plan would be prepared following the completion of detailed design. This would be done to retain or preserve as much of the existing vegetation as possible would be implemented, especially adjacent to drainage lines. Identification of any areas to be used as 'turn around' or laydown areas should be completed with an indication in the Construction Notes how cleared and NO-GO areas would be implemented e.g. GPS data provided to clearing contractors and areas flagged on the ground prior to any clearing activity.	Pre-construction
SW.36	Retain riparian vegetation and prevent offsite release of sediments.	DLRM Land Clearing Guidelines provide information on required buffer zones for watercourses (DLRM, 2013a and DLRM, 2013b). To be effective as a sediment control, the area for retention should contain at least 80% ground cover. Buffer zones for the Apirnta Facility, Chandler Facility, and Haulage Roads have been developed based on stream order. The bulk of buffer zones are 25 metres. The exception is Charlotte Creek, a second order stream, requiring a buffer of 50 metres.	Construction and operation
Historic and cultural heritage			
CH.1	Reduce the risk of inadvertently disturbing archaeological material during construction.	Undertake additional surveys of areas that would be impacted but have not yet been surveyed and which have a moderate to high probability of containing archaeological material (e.g. sections of	Pre-construction

ID	Outcome	Mitigation/management measure	Timing
		the proposed Chandler Haul Road and eastern end of the proposed Henbury Access Road).	
CH.2	Preservation of areas of cultural sensitivity.	Clearly mark cultural heritage exclusion zones and ensure there is no intrusion into cultural heritage exclusion zones.	Pre-construction, construction, operation, and closure and rehabilitation
CH.3	Appropriate consent obtained to impact or potentially disturb archaeological material.	Ensure that appropriate consent is obtained for all sites that would be directly impacted or vulnerable to disturbance and require protective measures. Consent would be obtained from the NT Heritage Branch under section 72 of the NT *Heritage Act.*	Pre-construction
CH.4	Mitigation and management of archaeological material within and in the vicinity of the proposed development footprint.	Undertake additional mitigative works as part of conditions associated with gaining consent to impact or disturb particular archaeological material. For example, establishing “no-go” areas, undertaking mitigative recording of sites, relocating artefacts and establishing protective fencing (refer to Table 11a through Table 11d of Cultural Heritage Management Plan, Appendix S).	Pre-construction
CH.5	Mitigation and management of archaeological material within and in the vicinity of the proposed development footprint.	Ensure that all cultural heritage resources within and in the vicinity of the proposed development footprint are identified on general site maps and that no-go areas (i.e. sites or parts of sites to be protected, restricted areas) are also shown on all construction drawings.	Pre-construction
CH.6	Facilitate the ongoing management of cultural heritage resources.	Establish a database of cultural heritage resources within and in the vicinity of the proposed development footprint.	Pre-construction
CH.7	Mitigation and management of archaeological material within and in the vicinity of the proposed development footprint.	Establish a cultural awareness induction program for all contractors, employees and agents working on-site. Maps and drawings showing cultural heritage resources within the proposed development footprint would be provided to all contractors and employees working on-site.	Pre-construction and construction
CH.8	Mitigation and management of archaeological material within and in the vicinity of the proposed development footprint.	Implement protocols for the unanticipated discovery of archaeological material and skeletal remains as per the Cultural Heritage Management Plan at Appendix S.	Pre-construction, Construction
CH.9	Mitigation and management of archaeological material within and in the vicinity of the proposed development footprint.	Ensure that sites identified as vulnerable to disturbance are subject to regular monitoring at monthly intervals. Implement management measures, if necessary (e.g. implementing works to stem erosion, reviewing the efficacy of site protection measures	Construction

ID	Outcome	Mitigation/management measure	Timing
		including fencing, the cultural heritage induction program and mapping).	
CH.10	Mitigation and management of archaeological material within and in the vicinity of the proposed development footprint.	Ensure that sites identified as vulnerable to disturbance are subject to monitoring on an annual basis. Implement conservation and management measures for other sites as appropriate (e.g. detailed recording, conservation works).	Operation
CH.11	Mitigation and management of archaeological material within and in the vicinity of the proposed development footprint.	Ensure any new areas subject to ground disturbance in the future are assessed and surveyed in accordance with the predictive models and appropriate actions taken in relation to the NT *Heritage Act*.	Operation
CH.12	Mitigation and management of archaeological material within and in the vicinity of the proposed development footprint.	Ensure that the condition of all sites are recorded one last time. Remove protective fencing once all infrastructure had been dismantled and removed from site and other rehabilitation works are complete. Forward all data pertaining to each site including site records, documentation (e.g. results of monitoring), photographs, records of action taken, etc. are forwarded to the NT Heritage Branch.	Decommissioning
Human health and safety			
HS.1	Minimisation of potential impacts on human health and the environment through responsible storage and handling of hazardous materials.	Finalise Safety Case for a Major Hazard Facility in accordance with the NT *Work Health Safety Act* and the NT WHS Regulations 536, 537 and 547 administered by NT WorkSafe and the Australian Dangerous Goods Code 2007.	Detailed design
HS.2	Minimisation of potential impacts on human health and the environment.	Finalise Emergency Response Management Plan.	Pre-construction
HS.3	Minimisation of potential impacts on human health and the environment.	Update Environmental Management System with management plans and procedures relevant to the construction, operation and closure and rehabilitation of the Proposal.	Pre-construction, construction, operation, closure and rehabilitation
HS.4	Minimisation of potential impacts on human health and the environment through responsible transportation, storage and handling of hazardous materials.	• Transport, store and handle hazardous materials in accordance with industry regulations, codes and standards (e.g. *Work Health and Safety (National Uniform Legislation)* Act and the NT WHS Regulations. • Adhere to Chandler Safety Case.	Construction, operation, closure and rehabilitation

ID	Outcome	Mitigation/management measure	Timing
		• Adhere to Chandler Waste Acceptance Procedure (WAP), Waste Acceptance Criteria (WAC) and Waste Zoning Guide (WZG). • Adhere to Emergency Response Management Plan.	
HS.5	Minimisation of potential impacts on human health and the environment through responsible transportation of hazardous materials.	• Transport hydrocarbons in compliance with the Australian Dangerous Goods Code 2007. • Ensure all vehicles are registered and carry appropriate equipment to respond to a spill, including personal protective equipment (PPE).	Construction, operation, closure and rehabilitation
HS.6	Minimisation of potential impacts on human health and the environment through responsible handling of hazardous materials.	Ensure personnel are trained in the appropriate handling of hazardous materials and in clean-up procedures in the event of a spill.	Construction, operation, closure and rehabilitation
HS.7	Minimisation of potential impacts on human health and the environment through responsible storage of hazardous materials.	Store diesel in 30,000 litre self-bunded tanks manufactured in compliance with Australian Standard (AS)1692 (Steel Tanks for Flammable and Combustible Liquids) and installed in compliance with AS1940 (The Storage and Handling of Flammable and Combustible Liquids).	Construction, operation
HS.8	Minimisation of potential impacts on human health and the environment through responsible storage of hazardous materials.	• Store lubricating oil in bulk containers inside a bunded area with spill protection and recovery kits. • Ensure waste hydrocarbons are stored in tanks inside a bunded area and held for collection by an appropriately licensed contractor for reprocessing and recycling.	Construction, operation
HS.9	Minimisation of potential impacts on human health and the environment through responsible storage and handling of hazardous materials.	Store ammonium nitrate in a dedicated building and in accordance applicable regulations, codes and standards. Ensure that ammonium nitrate is handled by appropriately trained personnel.	Construction, operation
HS.10	Minimisation of potential impacts on human health and the environment through appropriate clean-up of spills in	In the event of a spill of hazardous material, implement the strategies outlined in the Emergency Response Management Plan. These strategies would include (but would not be limited to): • Isolating and containing spill using spill kit.	Construction, operation, closure and rehabilitation

ID	Outcome	Mitigation/management measure	Timing
	accordance with Emergency Response Management Plan.	• Evacuating area if potential danger exists. • Notifying Environmental Manager. Provide location, extent, substance type, quantity, environments impacted (e.g. soils, surface watercourses, groundwater) and spill kit contents used. • Using spill kit to remove the contamination source or, where relevant, excavate and appropriately dispose of contaminated sediments. • Commencing investigation into soil, surface and/or groundwater impacts from the spill. Detail spill quantity, determine extent and significance of impact to human health and/or environment (including upstream/control samples, as required). • Providing DPIR with Section 29 Notification and NT EPA with Section 14 Incident Report Form within 24 hours of incident occurring if the incident caused or is threatening or may threaten to cause pollution resulting in minor or serious environmental harm. • Ensuring spill kits are located at all hazardous material storage locations. Spill kits would be available to be relocated to specific areas in accordance with scopes of work.	
HS.11	Minimisation of potential impacts on human health and safety (general).	Establish emergency medical safety points containing eye flush/body flush stations and first aid kits at easily identifiable key locations above and underground.	Construction, operation, closure and rehabilitation
HS.12	Minimisation of potential impacts on human health and safety (exposure from fuel spills).	• Adhere to WAP and WAC. • Wear appropriate PPE.	Construction, operation, closure and rehabilitation
HS.13	Minimisation of potential impacts on human health and safety (pedestrian and vehicle interactions).	• Develop Traffic Management Plan. The plan would include standard traffic rules, signage etc. It would also include collision avoidance system (refer to Chapter 18).	Construction, operation, closure and rehabilitation

ID	Outcome	Mitigation/management measure	Timing
		• Prepare and submit Construction Traffic Management Plan. • Prepare and submit Operational Traffic Management Plan (once detailed design has been completed). • Mark designated pedestrian areas. • Promote driver competency through training programs, as necessary.	
HS.14	Minimisation of potential impacts on human health and safety (exposure from mine gas extraction).	• Wear and maintain correct PPE (including breathing apparatus). • Aerate decline and shafts. • Undertake gas monitoring.	Construction and operation
HS.15	Minimisation of potential impacts on human health and safety (ventilation failure).	• Ensure there is a back-up supply of power. • Wear and maintain correct PPE (including breathing apparatus).	Construction, operation, closure and rehabilitation
HS.16	Minimisation of potential impacts on human health and safety (underground vehicle fire).	• Establish underground escape routes and isolation zones. • Ensure fire extinguishers and suppression systems are installed.	Construction, operation, closure and rehabilitation
HS.17	Minimisation of potential impacts on human health and safety (underground vehicle exhaust exposure).	• Consider use of electrical vehicles underground. • Wear and maintain correct PPE (including breathing apparatus, as appropriate). • Aerate decline and shafts. • Undertake gas monitoring.	Construction, operation, closure and rehabilitation
HS.18	Minimisation of potential impacts on human health and safety (heat stress - above and below ground).	• Remain hydrated and have a sufficient supply of water. • Wear and maintain correct PPE.	Construction, operation, closure and rehabilitation
HS.19	Minimisation of potential impacts on human health and safety (construction accidents).	• Install machine guarding.	Construction

ID	Outcome	Mitigation/management measure	Timing
		• Adhere to operational and maintenance procedures. • Ensure operator competency through training, as necessary.	
HS.20	Minimisation of potential impacts on human health and the environment (underground ignition).	• Adhere to Chandler WZG. • Undertake weekly gas monitoring in storage areas. • Ensure fire extinguishers and suppression systems are installed. • Install aeration system to maintain ventilation and restrict temperature rise.	Operation
HS.21	Minimisation of potential impacts on human health and safety (bites and stings).	• Wear appropriate PPE. • Use insect repellent.	Construction, operation, closure and rehabilitation
HS.22	Minimisation of potential impacts on human health and safety (drugs and alcohol abuse).	• Develop Drug and Alcohol Management Plan. • Implement daily testing for drugs and blood alcohol levels.	Construction, operation, closure and rehabilitation
HS.23	Minimisation of potential impacts on human health and safety (strata and ground stability).	• Correct design of room and pillar in the salt formation. • Wear and maintain correct PPE (including two-way radio).	Construction, operation, closure and rehabilitation
HS.24	Minimisation of potential impacts on human health and safety (mine and drill blasting).	• Ensure there is an adequate separation zone whilst blasting occurs. • Wear hearing protection. • Wear and maintain correct PPE.	Construction and operation
HS.25	Minimisation of potential impacts on human health and the environment (ignition of flammable materials).	• Adhere to Chandler WZG and Dangerous Goods Regulations. • Ensure fire extinguishers and suppression systems are installed.	Construction, operation, closure and rehabilitation
HS.26	Minimisation of potential impacts on human health and safety (fall from height).	• Ensure operator competency for working at heights. • Implement work at heights procedures. • Use suitable work at heights equipment e.g. fall protection.	Construction, operation, closure and rehabilitation

ID	Outcome	Mitigation/management measure	Timing
HS.27	Minimisation of potential impacts on human health and safety (electrical incident).	• Design and maintain all electrical systems as per legislative requirements. • Install physical protection (cabinets, bollards etc.) around high risk electrical installations.	Construction, operation, closure and rehabilitation
HS.28	Minimisation of potential impacts on human health and safety (exposure from radiation).	• Adhere to WAP and WAC. • Wear and maintain correct PPE.	Operation
HS.29	Minimisation of potential impacts on human health and safety (windblown materials).	• Factor local wind directions during placement of stockpiles. • Consider vegetation cover for long term stockpiles.	Construction and operation
HS.30	Minimisation of potential impacts on human health and safety (confined space).	• Ensure operational procedures are adhered to including those listed in the Air Quality Management Plan. • Ensure workers obtain confined space permits. Ensure operator competency in confined space entry. • Use breathing apparatus, where necessary. • Aerate decline and shafts. • Undertake gas monitoring.	Construction, operation, closure and rehabilitation
Economic and social			
ES.1	Management of expectations and maintenance of good working relationship with stakeholders.	Continue to engage in stakeholder consultation to inform stakeholders of forced or unpredicted delays. In particular, work with the NT Chamber of Commerce, the NT Government and the Industry Capability Network through the progression of the Proposal.	Pre-construction and construction
ES.2	High local content during construction and operation.	Commit to spending in the local region. Spending would directly benefit local businesses and their employees. It would also indirectly benefit other businesses in the local region through the spending on goods and services by these businesses.	Construction and operation
ES.3	Direct employment opportunities during construction and operation.	Commit to local employment. Provide opportunities to gain experience in construction and also long term work experience during operation.	Construction and operation

ID	Outcome	Mitigation/management measure	Timing
ES.4	Creation of opportunities for indigenous people from the local region to gain long term employment in a new industry.	Set target of 10% indigenous employment from the local region during construction and operation.	Construction and operation
ES.5	Creation of opportunities for employment of local people as well as indirect opportunities from flow on impacts.	Commit to local employment. This would increase job creation within the local region and NT.	Construction and operation
ES.6	Creation of large economic flow on impact from the Proposal. Some drawing of resources away from the rest of the local region and NT.	Commit to spending and employment in the local region. This would increase the economic value created in the local region and in the NT.	Construction and operation
ES.7	Increase in the ability of local people to purchase goods and services and to accumulate wealth.	Commit to local employment.	Construction and operation
ES.8	Boost to payroll taxation in the NT.	Commit to local employment. This would increase revenue from payroll taxation.	Construction and operation, and closure and rehabilitation
ES.9	Minimisation of stress on housing market (however there would be a low risk of impacting this market).	Commit to maximise the use of drive in – drive out employment over fly in – fly out employment which may encourage additional population to Alice Springs.	Construction and operation, and closure and rehabilitation
ES.10	Increased demand for goods and services through direct and indirect spending in the local region and NT.	Commit to local spending and employment as well as commit to ongoing consultation with local business organisations and government to maximise benefit to NT.	Construction and operation, and closure and rehabilitation
ES.11	Opportunities for new and existing businesses (e.g. agribusiness, tourism and conservation including ranger services and cultural and traditional tourism ventures) to support the Proposal.	Execute land use agreements with relevant parties. Land use agreements would generate a range of potential business opportunities for businesses in the local region and in the NT.	Pre-construction
ES.12	Opportunities for education and training of local people, in addition to new business opportunities for local businesses involved in the education and training sector.	Develop a Workforce Management Plan. Measures included in the plan would include a commitment to conduct training for employees in the local region and to also source training providers from the local region.	Pre-construction

ID	Outcome	Mitigation/management measure	Timing
ES.13	Benefits to local road users including tourists from residual road infrastructure (including the Henbury Access Road, Chandler Haul Road and upgrades to Maryvale Road).	Ensure Henbury Access Road and Chandler Haul Road are made available to pastoralists post closure and rehabilitation of the Proposal.	Closure and rehabilitation
ES.14	Positive health and education impacts within the local region.	Commit to the sponsorship of sporting and academic programs within the community of Titjikala.	Construction and operation, and closure and rehabilitation
ES.15	Reduced impacts from increased vehicle movements on Maryvale Road, Chambers Pillar Road, Stuart Highway.	Commit to workplace programs regarding road safety and develop and implement a Traffic Management Plan.	Pre-construction, construction and operation, and closure and rehabilitation
ES.16	Protection of culturally important sites.	Maintain and respect cultural heritage exclusion zones. Continue consultation with Traditional Owners and nearby residents throughout the life of the Proposal.	Construction and operation, and closure and rehabilitation
ES.17	Some interaction between workers and local residents possible, but unlikely.	House workers in accommodation village. Maintain strict workplace regulations which minimise interaction with local residents and promote responsible behaviour.	Construction and operation, and closure and rehabilitation
Closure and rehabilitation			
CR.1	Return of the development footprint to near original condition.	Adopt the principles set out in the draft RCP (refer to Appendix L). Such principals would include (but would not be limited to): • Decontaminate structures (if necessary) and wash down prior to the commencement of demolition works. • Determine safe and efficient dismantling procedures and prepare a demolition plan. • Pull structures to ground and dismantle. • Break down concrete slabs and footings to a depth of one metre below the finished ground surface. • Remove or bury services at a depth of at least one metre below the final ground surface. • Leave buried pipes *in situ* and flush and seal each end.	Closure and rehabilitation

ID	Outcome	Mitigation/management measure	Timing
		• Dispose of non-recyclable and inert waste in an on-site landfill, or similar. • Ensure access roads required to be left for post closure monitoring purposes are defined and retained. All areas are ripped to break compaction prior to overburden and/or topsoil application.	
CR.2	Monitoring of rehabilitation and annual reporting on performance and objectives.	Undertake monitoring of rehabilitation (including vegetation regrowth) and annual reporting on performance and objectives. Includes monitoring of vegetation regrowth and surface water and groundwater monitoring as per the requirements of the Water Management Plan (refer to Appendix Q).	Closure and rehabilitation
CR.3	Maintenance works/remedial action taken, if needed.	Should visual inspections or monitoring results indicate the need for maintenance works or remedial action to be undertaken, mobilise contractors to site to undertake these works. Works may include: • Vegetation – if rehabilitation is failing, additional application of fertiliser, additional seeding or planting may be required. • Erosion - if significant erosion is identified or rehabilitation is not progressing towards a self-sustaining community, the following remedial actions may be considered: o Construct, improve, or repair drainage control measures to reduce water movement down outer slopes of the landform. o Remediate areas of deep erosion and/or instability with appropriate material. Access - remedial works would be required if access prevention measures fail to restrict unauthorised access.	Closure and rehabilitation
Bushfire			
BF.1	Reduced incidence of bushfire (protection of human life, assets and the environment).	Finalise draft Bushfire Management Plan prior to construction and incorporate into the CEMP, OEMP and RCP. The plan collates	Pre-construction

ID	Outcome	Mitigation/management measure	Timing
		measures to mitigate and manage potential impacts on the humans, assets and the environment.	
BF.2	Reduced incidence of bushfire (protection of human life, assets and the environment).	Undertake fuel load assessments annually to assess bushfire potential and need for pro-active controls, e.g. back burning.	Construction, operation, closure and rehabilitation
BF.3	Reduced incidence of bushfire (protection of human life, assets and the environment).	Create fire breaks/asset protection zones with reference to prevailing wind directions, highest wind speeds and vegetation types.	Construction, operation, closure and rehabilitation
BF.4	Reduced incidence of bushfire (protection of human life, assets and the environment).	Consult with the NT Fire and Rescue Service on issues relating to: • Strategic planning of bushfire with respect to the layout of the Chandler Facility. • Fire safety. • Hazard abatement. • Firefighter training. Operations support and administration.	Pre-construction, construction and operation
BF.5	Reduced incidence of bushfire (protection of human life, assets and the environment).	Ensure bushfire suppression equipment is available on-site.	Construction, operation, closure and rehabilitation
BF.6	Reduced incidence of bushfire (protection of human life, assets and the environment).	Ensure fuels and other flammable materials are stored appropriately and in accordance with applicable regulations.	Construction, operation, closure and rehabilitation
Air quality			
AQ.1	Minimisation of air quality and human health impacts.	Prepare an Air Quality Management Plan.	Pre-construction
AQ.2	Minimisation of dust and associated human health risks.	Ensure effective communication between potentially affected communities and the proponent.	Construction
AQ.3	Minimisation of dust and associated human health risks.	Perform daily on-site and off-site inspections.	Construction
AQ.4	Minimisation of dust and associated human health risks.	Promote a program of considerate vehicle operation and sustainable travel.	Construction
AQ.5	Minimisation of dust and associated human health risks.	Use enclosed tankers for the transportation of bulk materials.	Construction

ID	Outcome	Mitigation/management measure	Timing
AQ.6	Minimisation of dust and associated human health risks.	Implement measures to ensure that vehicle track-out is adequately controlled.	Construction
AQ.7	Minimisation of dust and associated human health risks.	Establish a dust monitoring network to monitor dust emissions within the development envelope. Dust monitors would likely be installed at: • Chandler Facility • Apirnta Facility • Accommodation village • Community of Titjikala.	Construction
AQ.8	Minimisation of particulate emissions from mine surface operations.	Ensure use of diesel engines that comply with the emission standards of the United Stated Environmental Protection Agency (Tier 4 Emission Standards).	Operation
AQ.9	Minimisation of particulate emissions from mine surface operations.	Install windbreaks at run-of-mine salt stockpiles.	Operation
AQ.10	Minimisation of particulate emissions from mine surface operations.	Install windbreaks at sandstone, shale, limestone and topsoil stockpiles. In addition to windbreaks, shape and profile and rehabilitate stockpiles, as necessary.	Operation
AQ.11	Minimisation of dust and associated human health risks.	Enforce vehicle speed restrictions, undertake surface improvements or surface treatments (including wet suppression and chemical stabilisation).	Operation
AQ.12	Minimise risk of loss of containment of waste materials.	Ensure handling of IBC/FIBC from TEU containers is performed on a strict one-at-a-time basis, to avoid the potential for spillage of contents of multiple containers.	Operation
AQ.13	Minimise risk of loss of containment of waste materials.	Ensure containers are removed from trucks in an appropriately bunded area to minimise the surface area of any spills and to enable efficient clean-up of any spilled materials. Ensure liquid waste is managed through a liquid waste collection system designed to allow for sufficient capacity of liquids to be removed (e.g. 110% of potential spill volume).	Operation
AQ.14	Minimise risk of loss of containment of waste materials (transportation).	Develop a collision avoidance system that provides a visible and audible positive confirmation of the presence of other vehicles travelling along the proposed Chandler Haul Road. Visible and audible alarm would alert drivers when haul trucks are within 500 metres of each other, requiring a reduction in speed.	Operation

ID	Outcome	Mitigation/management measure	Timing
AQ.15	Minimise risk of loss of containment of waste materials (transportation).	Restrict loads containing common and/or more toxic waste components, such that: • Less than one TEU equivalent is carried in one movement. Less than one TEU equivalent is carried in any two sequential movements (to manage out the potential of loss of containment from collisions).	Operation
AQ.16	Minimise risk of loss of containment of waste materials (transportation).	Manage loss of containment at Orange Creek, Desert Oaks Motel, Stuart Wells and at the Apirnta Facility through the implementation of specific mitigation measures, which include: • A pre-prepared management response plan would be prepared for each location. • Restrictive speed limits imposed for road transport as it passes each of the locations. • The content of the response plan would need to be communicated to the respective residents, and also posted prominently for public reference in the unlikely event of a loss of containment at those locations. The provision of spill kits at each location.	Operation
Noise and vibration			
NV.1	Workers safeguarded from occupational noise.	Prepare Noise Management Plan (in accordance with the NT *Work Health Safety Act*) prior to construction and incorporate into the CEMP, OEMP and/or RCP for the Proposal.	Pre-construction
NV.2	Workers safeguarded from occupational noise.	Select mobile mechanical equipment to minimise noise emissions and ensure equipment is appropriately maintained to ensure excessive noise is not generated.	Construction, operation, closure and rehabilitation
NV.3	Workers safeguarded from occupational noise.	Check noise emission levels of all critical items of mobile mechanical equipment for compliance with noise limits appropriate to those items prior to the equipment going into regular service.	Construction, operation, closure and rehabilitation
NV.4	Workers safeguarded from occupational noise.	Where practicable, operate mechanical equipment at low speed/power and switch off when not being used rather than leave idling for prolonged periods of time.	Construction, operation, closure and rehabilitation

ID	Outcome	Mitigation/management measure	Timing
NV.4	Workers safeguarded from occupational noise.	Provide appropriate training for operators in order to raise their awareness of potential noise problems and to increase their use of techniques to minimise noise emissions.	Construction, operation, closure and rehabilitation
NV.5	Workers safeguarded from occupational noise.	Where practicable, optimise the layout and positioning of noise-producing equipment and activities on-site to minimise noise emission levels.	Construction, operation, closure and rehabilitation
NV.6	Workers safeguarded from occupational noise.	Ensure workers wear and maintain appropriate PPE.	Construction, operation, closure and rehabilitation
NV.7	Workers safeguarded from occupational noise.	Where noise from a particular activity is identified, measures to mitigate the impact would be investigated, implemented and recorded.	Construction, operation, closure and rehabilitation
Visual amenity			
LV.1	Landscape management.	Prepare a Landscape Concept Plan as part of the detailed design of the Proposal. Measures in the plan would include the consideration of existing landscape features when siting infrastructure and choosing building materials and treatments to minimise the potential visibility of the Proposal.	Detailed design
LV.2	Avoid visual impacts on potential items of cultural sensitivity.	Consult with Traditional Owners during the detailed design of the Proposal.	Detailed design
LV.3	Screening of infrastructure.	Where possible, utilise existing features of the landscape, such as existing shrubs and trees, to screen and minimise visual impacts of infrastructure and/or permanent structures.	Detailed design
LV.4	Complement the existing landscape.	Choose external building finishes to minimise visual impact. Recessive, low reflectivity finishes that blend with the adjoining bushland wold be used. Roof colours and finishes would complement the colour of the building facades and the hues would aim to blend with the colours prevailing in the surrounding landscape.	Detailed design
LV.5	Minimise the impact of uncharacteristic features in the landscape.	Avoid the use of highly reflective surfaces/colours, brightly coloured or strongly contrasting materials, and unpainted metal.	Detailed design
LV.6	Minimise the impact of uncharacteristic features in the landscape.	Ensure boundary fences are simple, non-reflective and have a high degree of transparency.	Detailed design
LV.7	Mitigate plant loss and screening of infrastructure.	Plant trees (in accordance with the recommendations of the Biodiversity Management Plan) to reduce the visual impacts of the	Prior to operation

ID	Outcome	Mitigation/management measure	Timing
		Proposal. Tree planting would give scale to the buildings, provide amenity (shade) for employees, and screen areas, such as stockpiles and hardstand areas.	
LV.8	Provide future ecological opportunities.	Ensure native and endemic species are used during tree planting to ensure that the existing landscape character is retained.	Prior to operation
LV.9	Avoidance of bushfires.	Ensure trees are planted on the perimeter of hardstand areas and out of the bushfire buffer zones.	Construction and operation
Public health and food			
PHF.1	Adherence with the environmental health requirements of the NT Department of Health – Environmental Health.	Design, construct and operate the Proposal in accordance with the requirements set out in the NT Department of Health – Environmental Health *Environmental Fact Sheet No. 700: Requirements for Mining and Construction Projects* (2014).	Pre-construction, construction and operation
PHF.2	Adherence with food safety requirements of the NT Department of Health – Environmental Health.	Register the proposed accommodation village with the NT Department of Health – Environmental Health in accordance with the NT *Food Act.*	Pre-construction
PHF.3	Adherence with food safety requirements of the NT Department of Health – Environmental Health.	Design accommodation village to meet the minimum standards prescribed by the National Food Safety Standards prescribed by Food Standards Australia New Zealand and in accordance with Australian Standard (AS) 4674 *Design, Construction and Fit-out of Food Premises.*	Pre-construction
PHF.4	Adherence with food safety requirements of the NT Department of Health – Environmental Health.	Submit detailed plans and specifications of the accommodation village with regard to food safety (prior to construction) to the relevant Environmental Health Officer within the NT Department of Health.	Pre-construction
PHF.5	Adherence with food safety requirements of the NT Department of Health – Environmental Health.	Register accommodation village following assessment and approval (prior to operation) with the relevant Environmental Health Office.	Pre-operation
PHF.6	Adherence with staff accommodation and sanitary facilities requirements of the NT Department of Health – Environmental Health.	Maintain accommodation village in accordance with the NT *Public and Environmental Health Act* and with the requirements set out by NT Department of Health – Environmental Health in the *Public and Environmental Health Guidelines for Public Accommodation* (2014).	Operation

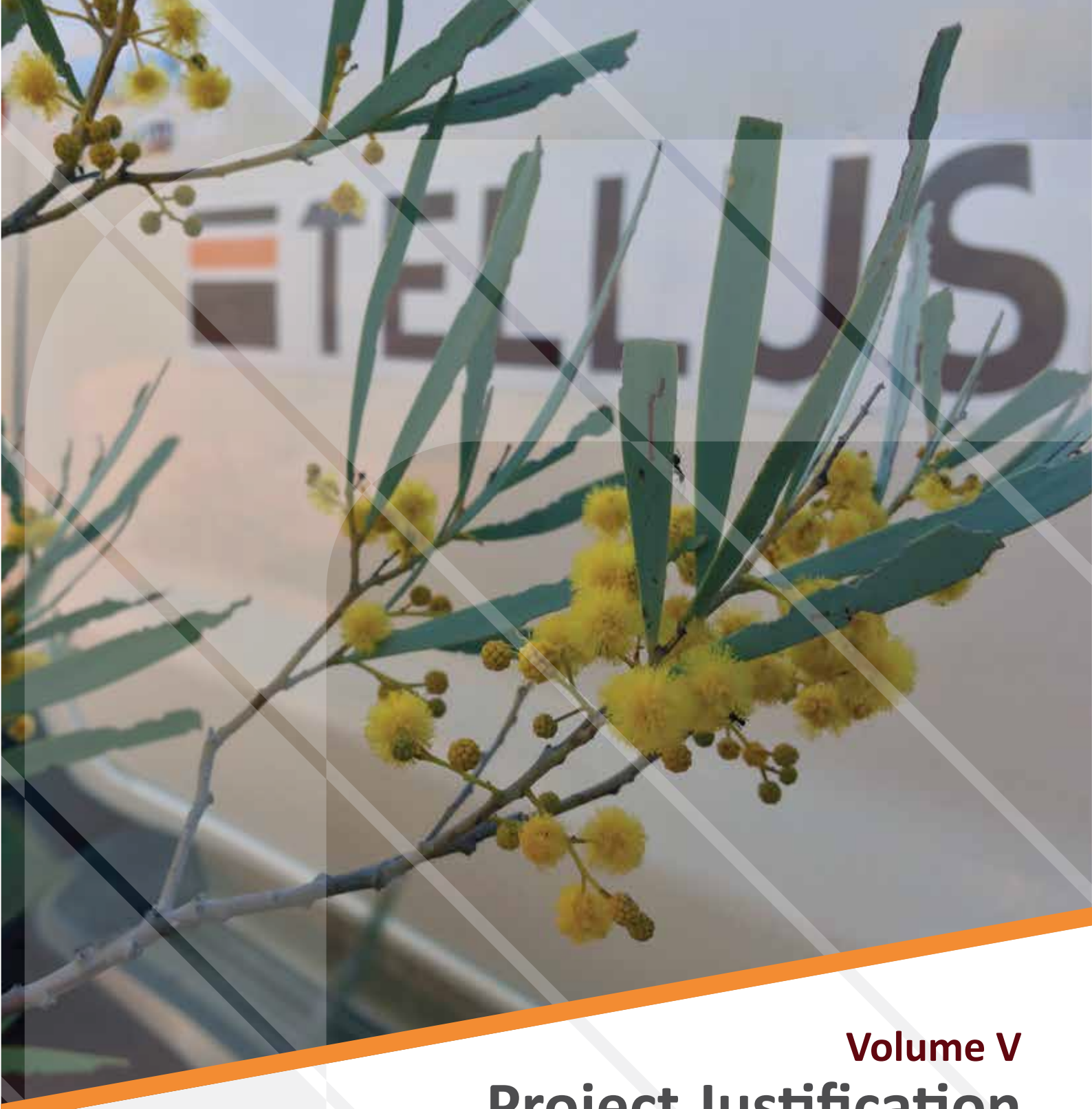
ID	Outcome	Mitigation/management measure	Timing
PHF.7	Adherence with staff accommodation and sanitary facilities requirements of the NT Department of Health – Environmental Health.	Provide an adequate number of sanitary facilities at the proposed accommodation village in accordance with the Building Code of Australia.	Operation
PHF.8	Adherence with staff accommodation and sanitary facilities requirements of the NT Department of Health – Environmental Health.	Submit detailed plans and specifications of the accommodation village with regard to staff accommodation and sanitary facilities (prior to construction) to the relevant Environmental Health Officer within the NT Department of Health.	Pre-construction
PHF.9	Adherence with staff accommodation and sanitary facilities requirements of the NT Department of Health – Environmental Health.	Register accommodation village following assessment and approval (prior to operation) with the relevant Environmental Health Office.	Pre-operation
PHF.10	Adherence with on-site wastewater disposal requirements of the NT Department of Health – Environmental Health.	Submit aerated wastewater treatment system for wastewater works design approval by the NT Department of Health – Environmental Health in accordance with the provisions of the NT *Public and Environmental Health Act* and Public and Environmental Health Regulations.	Pre-construction
PHF.11	Adherence with on-site wastewater disposal requirements of the NT Department of Health – Environmental Health.	Obtain approval for liquid trade waste pre-treatment device(s) at the accommodation village from the NT Power and Water Corporation – Trade Waste Section.	Pre-construction
PHF.12	Adherence with potable water supply requirements of the NT Department of Health – Environmental Health.	Potable water would be routinely analysed to ensure that it meets the requirements of the *Australian Drinking Water Guidelines (2011) – Updated February 2016* developed by the by the National Health and Medical Research Council in collaboration with the Natural Resource Management Ministerial Council. In addition, a general chemical and metals analysis would also be routinely undertaken.	Construction and operation
PHF.13	Adherence with bores requirements of the NT Department of Health – Environmental Health.	Ensure that bores within the borefield are constructed to the standards outlined in the *Minimum Construction Requirements for Water Bores in Australia, Third Edition* (Australian Government National Water Commission 2012).	Pre-construction
PHF.14	Adherence with bores requirements of the NT Department of Health – Environmental Health.	Ensure that bore setbacks to on-site wastewater disposal would be in accordance with the NT *Code of Practice for On-site*	Pre-construction

ID	Outcome	Mitigation/management measure	Timing
		Wastewater Management (Environmental Health Program Directorate Territory Health Services 2014).	
PHF.15	Adherence with fuel storage requirements of the NT Department of Health – Environmental Health.	Ensure that fuels are stored and handled on-site in accordance with AS 1940-2004 *Storage and Handling of Flammable and Combustible Liquids.*	Construction, operation, and closure and rehabilitation
PHF.16	Responsible disposal of solid waste.	Solid waste would be collected in designated bins and trucked off-site to appropriately licenced waste facilities in Titjikala or Alice Springs, as appropriate.	Construction, operation, and closure and rehabilitation
PHF.17	Reduce off-site disposal of food waste.	Explore opportunities for composting food waste during detailed design of the Proposal.	Construction
PHF.18	Adherence with public health nuisance abatement requirements of the NT Department of Health – Environmental Health.	Implement mitigation measures listed under groundwater, surface water and air quality.	Construction, operation, and closure and rehabilitation
PHF.19	Adherence with occupational health and safety requirements of the NT Department of Health – Environmental Health.	Ensure that activities associated with construction, operation, and closure and rehabilitation are carried out in accordance with occupational health and safety legislation administered by NT WorkSafe and in accordance with the Safety Case.	Construction, operation and, and closure and rehabilitation
PHF.20	Adherence with environmental management plan requirements of the NT Department of Health – Environmental Health.	Provide relevant sections of the CEMP and OEMP to the Environmental Health Office for review and comment prior to construction and operation.	Pre-construction and pre-operation
Biting insects			
BI.1	Negligible increase in biting insects and protection of personnel from biting insects.	Finalise draft Biting Insect Management Plan prior to construction and incorporate into the CEMP and OEMP. The plan collates measures to mitigate and manage potential impacts on biodiversity.	Pre-construction
BI.2	Protection of personnel from biting insects.	Implement personnel protection measures in accordance with the NT Government Department of Health Guidelines *Personal Protection From Mosquitoes and Biting Insects in the NT*.	Construction, operation, closure and rehabilitation
BI.3	Negligible increase in biting insects.	Control and manage potential mosquito breeding sites in accordance with the NT Government Department of Health *Guidelines for Preventing Mosquito Breeding Sites Associated with Mining Sites.*	Construction, operation, closure and rehabilitation

ID	Outcome	Mitigation/management measure	Timing
BI.4	No ponding of water (no breeding habitat for mosquitos).	Ensure containers capable of ponding water are stored under cover, contain drainage holes, are emptied within five days, are treated with appropriate insecticide or disposed of appropriately according to the Waste Management Plan.	Construction, operation, closure and rehabilitation
BI.5	Protection of personnel from biting insects.	Ensure accommodation village is adequately screened.	Construction
BI.6	Negligible increase in biting insects.	Ensure no actual or potential mosquito breeding sites remain after decommissioning of the Proposal. Ensure disturbed areas are rehabilitated and free draining. Remove infrastructure that has the potential to pond water.	Closure and rehabilitation
Greenhouse gas			
GHG.1	Minimise greenhouse gas emissions.	Ensure vehicles/plant and machinery are turned off when not in use and regularly serviced to ensure efficient operation.	Construction, operation, closure and rehabilitation
GHG.2	Minimise greenhouse gas emissions.	Design truck routes and loading capacity to reduce the distance and effort required by vehicles.	Construction
GHG.3	Minimise greenhouse gas emissions.	Use B5 and E10 fuel in plant and equipment, where possible.	Construction, operation, closure and rehabilitation
GHG.4	Minimise greenhouse gas emissions.	Perform regular energy and water audits.	Operation
GHG.5	Minimise greenhouse gas emissions.	Install window blinds in all office areas.	Construction
GHG.6	Minimise greenhouse gas emissions.	Maximise the area covered by the solar farm to minimise fuel used in electricity generation.	Construction
GHG.7	Minimise greenhouse gas emissions.	Install sensor lighting to minimise the number of lights being operated when not required.	Construction
GHG.8	Minimise greenhouse gas emissions.	Use, energy efficient lighting, where possible.	Construction
GHG.9	Minimise greenhouse gas emissions.	Develop building maintenance policies and a building user guide to ensure efficient operation of plant and equipment.	Operation
GHG.10	Minimise greenhouse gas emissions.	Develop heating, ventilation and air conditioning key performance indicators and building performance targets.	Operation

ID	Outcome	Mitigation/management measure	Timing
GHG.11	Minimise greenhouse gas emissions.	Ensure sub-metering is in place to monitor electricity and water consumption throughout the Proposal.	Operation
Traffic			
T.1	Minimise traffic and transportation impacts.	Prepare and implement a Traffic Management Plan in consultation with the NT Department of Transport.	Pre-construction
T.2	Minimise traffic and transportation impacts.	Install appropriate speed and warning signage prior to and at the crossing of Chambers Pillar Road.	Construction
T.3	Prevention of accidents between trucks hauling waste and salt along the Chandler Haul Road.	Develop a collision avoidance system for the Chandler Haul Road. Include the provision of a visible and/or audible alarm system to confirm the presence of vehicles traveling along the proposed Chandler Haul Road. Alarm system would alert drivers of haul trucks when another truck is within 500 metres, requiring a reduction in speed.	Operation
T.4	Minimise traffic and transportation impacts.	Restrict speed limits to no more 60km/hr on the proposed Chandler Haul Road and Henbury Access Road. Ensure vehicles reduce speed and come to a complete stop at the crossing of Chambers Pillar Road.	Construction, operation, closure and rehabilitation
T.5	Minimise traffic and transportation impacts.	Commit to workplace programs regarding road safety.	Construction, operation, closure and rehabilitation
T.6	Access to surrounding properties maintained.	Maintain access to surrounding properties for the duration of the Proposal.	Construction, operation, closure and rehabilitation

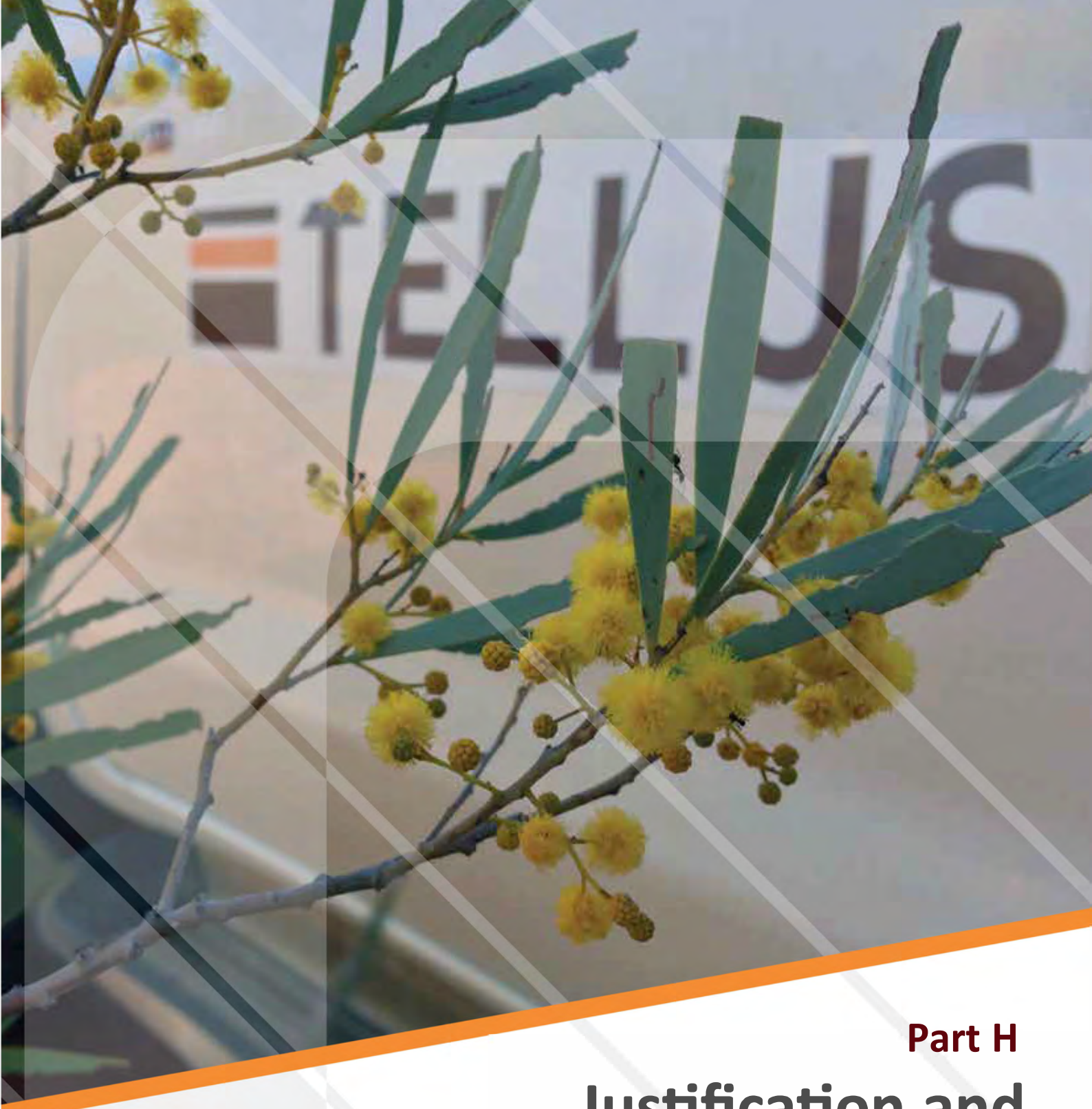
.



Volume V

Project Justification and Conclusion

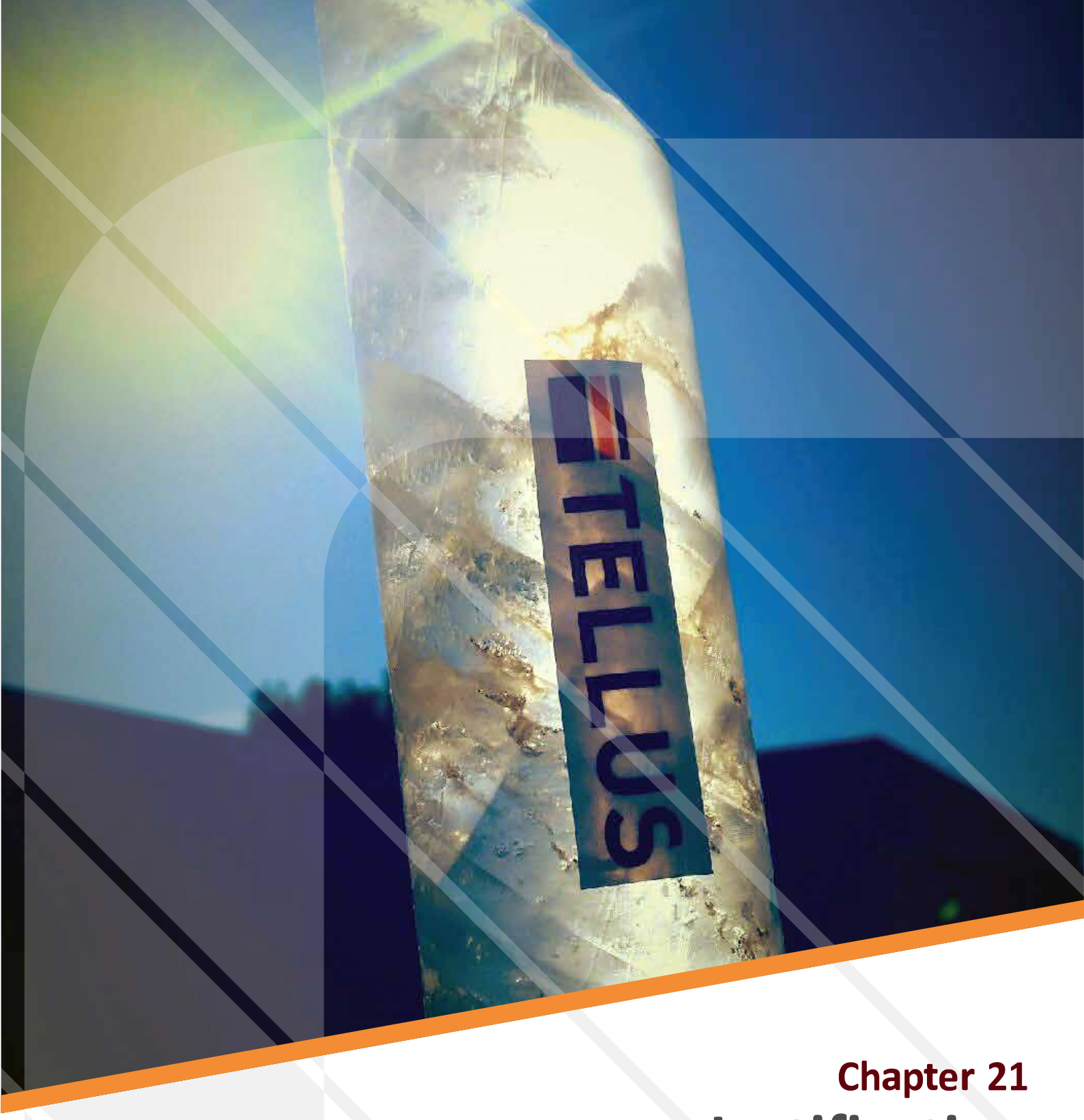
TELLUS



Part H

Justification and Conclusion

TELLUS



Chapter 21
Justification

This page has been left intentionally blank

21 JUSTIFICATION

21.1 Proposal benefits

The Proposal is considered to be justified because it:

- Responds to a recognised need and is consistent with state and national waste management strategies.
- Provides many social and economic benefits including opportunities for long-term, full time employment.
- Would not result in significant adverse effects on the environment.
- Is consistent with the principles of ecologically sustainable development.

Proceeding with the Proposal would result in significant social and economic benefits in the NT and within Australia. The Proposal would:

- **Provide an innovative unique dual revenue business in remote Central Australia** -the business would commercialise an industrial bulk commodity (salt) and provides an equipment and archives storage business and a storage, recovery and permanent isolation business for hazardous waste generated in the NT and within Australia.
- **Diversify the economy.** - development of enabling environmental infrastructure which would assist in providing utility support services to other existing and new projects that generate waste as a result of the 'Developing the North' strategy.
- **Major investment in regional Australia** - the capital expenditure is estimated to be around A$676 million (nominal, including finance and contingency) for the Proposal. Around 67 % of all construction costs would be spent in Australia (36% spent in the NT).
- **Boost the economy over the 29-year project life** - on average, there would be spending of just under $81 million per annum to operate the Proposal. Of this, 64 % would be spent in Australia (a total of 52% would be spent in the NT). The site could be expanded for generations.
- **Royalties, taxes and levies** - over the 29-year term could support other parts of the NT and the Australian economy.



Plate 21-1 Tellus has supported indigenous jobs during the development of the EIS and would continue to support indigenous employment through the construction, operation, and closure and rehabilitation of the Proposal.

- **Create training and long term job opportunities** -
    - About 270 jobs during construction (720 jobs during peak build including in-directs).
    - About 150 to 180 full time equivalent workers would be employed during operation. Just over 5,400 full-time equivalent job years would be created over the life of the Proposal, an average of 217 full time equivalent job years per annum.
    - Jobs would be green, sustainable, and generally well paid covering technical (engineering, chemistry, science), commercial (sales, business) and operational skills.
    - Proposed jobs and training programs, such as:
        - 1. Tellus' School to Jobs Program (Annual Schools Tour).
        - 2.Tellus' Pre-employment Training Program ('Getting Job Ready') comprising Tellus' Traineeships Program, Tellus' Apprenticeships Program and Training Accreditation.
        - 3. Indigenous Employment Program; comprising a 10 % indigenous employment target as well as other commitments that would benefit local indigenous people such as the sponsorship of sporting and academic programs in the nearby community of Titjikala (refer to Plate ES-2 and Plate ES-3).
        - 4.Tellus' Employment Programs and Systems comprising a 'Sisters in Mining' Program; Tellus' Disabled Worker Program, Tellus' Ranger Program and support for Social Enterprises that could generate more jobs.
- **Provide local business support and new business opportunities** - goods and services such as construction and operational materials, food, accommodation, etc. would be sourced from local business, where possible.
- **Fulfil the government's own environmental and waste policy obligations under the following four main regulatory regimes** -
    - Environmental protection regulations (to minimise adverse impacts on the environment and human health and to meet national and international obligations);
        - Meeting NT and national obligations by providing critical infrastructure that can safely store, recover or permanently isolate difficult to manage wastes.
        - Meeting international obligations under the Basel Convention (Regulation of Transboundary Movements) and Waigani Convention (Regulation of Exports and Imports) by providing critical infrastructure for our near-neighbors such as the Pacific Islands who do not have suitable infrastructure to manage such wastes. Australia currently exports waste mostly to Europe and Asia and imports small volumes of waste materials mostly from our near neighbors (Pacific Islands). The proponent is not planning on actively

marketing this service, but in the event of a man-made or natural disaster, the proposed Chandler Facility would be suitable.

- Transport of dangerous goods regulations (to prevent accidents and promote safe transport, regulated by national legislation and codes).
- Work health and safety regulations (hazardous chemical regulations that reduce occupational health and safety risk in the workplace).
- Product stewardship regulations (the responsible management of products such as waste oil, asbestos, e-waste, tyres, batteries, mercury, medicines).

- **Support the circular economy** - by providing an opportunity for the future potential recovery of valuable materials (that are currently deemed waste). The Proposal could attract new salt and waste recycling and recovery industries to the NT.



Plate 21-2 Tellus would continue to support the local community through construction and operation of the Proposal.

21.2 Environmental impacts

Investigations were undertaken to assess the potential environmental impact during construction, operation and closure and rehabilitation of the Proposal. These included specialist studies of biodiversity, groundwater, surface water, historic and cultural heritage, social, economic, air quality (including a greenhouse gas assessment and risks to human health) and noise and vibration. The potential environmental impacts of the Proposal are documented and mitigation and management measures identified to avoid and reduce potential impacts and to protect the environment.

Based on the environmental assessment, the Proposal would result in the following environmental effects:

- **Biodiversity**. Construction of the Proposal would result in the removal of approximately 397.5 hectares of vegetation. The removal of this vegetation would result in the loss of fauna foraging, breeding, roosting, sheltering and/or dispersal habitat. Activities associated with construction and closure and rehabilitation may result in indirect impacts including habitat fragmentation, fauna displacement, injury or mortality; fauna strike; edge effects; altered

hydrology; contamination; erosion and sedimentation; dust; increased light, noise and vibration; the introduction and spread of weeds and invasive species; increased predator species; increased introduced fauna use; and an increased incidence of fire. Indirect impacts during construction may include fauna strike; altered hydrology; contamination; increased light, noise and vibration; the introduction and spread of weeds and invasive species; an increased incidence of fire; and potential impacts associated with salt runoff and windblown salt from stockpiles.

There would be no significant impact on species listed as near threatened or data deficient under the TPWC Act, nor would there be significant impacts on species listed as threatened under the TPWC Act and/or EPBC Act. At present, no biodiversity offsets are deemed necessary as there would be no significant impact to matters of national environmental significance during construction, operation, or closure and rehabilitation of the Proposal.

- **Groundwater.** The absence of permanent surface water features across the proposed development footprint means that the groundwater and surface water systems are not connected in the vicinity of the proposed Chandler Facility or the proposed Apirnta Facility. Shallow groundwater levels and gradients within the alluvium groundwater system indicate some potential for connectivity to the south-east along the Finke River about 20 kilometres from the Chandler Facility. The Proposal would cause localised changes to the groundwater conditions due to groundwater abstraction demands and potential mine dewatering arising from induced groundwater inflow.

  The local groundwater systems are considered to be compartmentalised, with flow and storage restricted by claystone and siltstone aquitards, and as such potential impacts to surrounding receivers are significantly negated by the disconnection of these systems. Springs observed to be discharging along the Finke River (e.g. Horseshoe Bend Spring) about 20-50 kilometres south-south-east of the Chandler Facility are inferred to be deriving their source of water from perched shallow alluvium, and are therefore understood to be isolated from potential dewatering impacts arising from mining within the deeper local groundwater systems.

  Any groundwater intercepted by the construction of subsurface works is likely to result in the dewatering of the localised perched groundwater systems. Due to the isolated extent of any shallow perched systems, the stratified nature of the underlying deeper aquifers, and the 90 metre depth to groundwater, dewatering impacts arising from mining operations would be localised in extent and would not impact nearby sensitive receivers or GDE's.

  The conceptual model concluded that abstraction from the Langra Formation at the rate specified for construction and operation of the Proposal would result in localised drawdown (as demonstrated by the PB1 constant rate test over five days at 4 L/s). A similar dynamic response in groundwater levels is expected within the Stairway Sandstone along the Chandler Haul Road, with abstraction demands for dust suppression likely to result in localised drawdown. Impacts of localised drawdown within the Stairway Sandstone have the potential to extend to three surrounding landholder bores (RN10082, RN14492, and RN14584) but residual risks have been determined as low.

Elsewhere, the relatively minor drawdown associated with Proposal-related abstraction is unlikely to cause any impacts of concern to other sensitive landholder bore and environmental groundwater users.

It should also be noted that the drawdown impacts arising from the Proposal would be of such low magnitude and extent that they would not reach the spring areas. This is due to the low rate of groundwater pumping throughout the Proposal life (1.7 L/s, which is broadly consistent with stock and domestic rates), and also the limited extent of drawdown due to the relatively low permeability aquifer units, and the intervening aquitard units.

- **Surface water.** The Proposal is located in a remote, dry and sparsely populated part of the NT. Watercourses in the region are generally dry for the majority of the year. Rainfall is seasonal, with the potential to generate large flood events. Due to generally dry antecedent conditions, the first rain to fall is needed to satisfy the moisture demand of the surface layer, with runoff generated from rain later in the storm.

  Without suitable mitigation, flooding has the potential to affect the proposed Chandler Facility, Apirnta Facility and the Chandler Haul Road. Mitigation would be required to divert/convey flood flows from upstream catchments past the Chandler Facility and Apirnta Facility, and to manage stormwater falling on both sites. Stormwater management would include water quality treatment.

  Where the proposed Henbury Access Road and Chandler Haul Road crosses drainage lines, the roads could be closed for up to 24 hours following the 100-year ARI 9-hour storm unless mitigation measures (culverts or causeways) are incorporated into the road design. The crossing of the Finke River (between the Apirnta Facility and the Stuart Highway) could require a bridge, if that section of road is to be kept open.

  If managed correctly, the remote location of the Proposal limits the potential for the associated infrastructure to adversely affect other communities or the environment. The changes in hydrological regime due to the mine site development are unlikely to be observed at the Titjikala community near the Hugh River, as the affected area is a small percentage of the contributing catchment and hydrological connectivity from the proposed mine site area through the washout zone and dunes to the Hugh River is unlikely.

- **Historic and cultural heritage**. No historic items would be impacted during construction or operation of the Proposal. With regards to archaeological material, at least three site complexes, 11 individual sites, three background scatters and 11 isolated finds would be directly impacted during the construction of the Proposal. In addition, at least two site complexes, four individual sites, three background scatters and six isolated finds may be vulnerable to disturbance during construction given their close proximity to the proposed development footprint. Appropriate consent would be obtained for all sites that would be directly impacted or vulnerable to disturbance (and requiring protective measures). Consent would be obtained from the NT Heritage Branch under Section 72 of the NT Heritage Act. Additional mitigation and management measures to preserve cultural heritage values would

be included in a Cultural Heritage Management Plan as part of the CEMP, OEMP and RCP for the Proposal.

- **Air quality.** The assessment has shown that pre-mitigated construction and operation risks on air quality range from neutral to major. Major risks relate to the transport of solid and liquid waste materials. Outline measures for managing and monitoring the impacts of air quality have been considered with respect to the receiving environment and human health. In addition, the Proposal would prepare a construction and operation Air Quality Management Plan. Post mitigation construction and operation risks on air quality were assessed. With mitigation and management measures in place, risks were reduced. They ranged from neutral to intermediate. The Proposal would be acceptable from an air quality and human health perspective.

Mitigation measures that would be implemented during construction, operation and closure and rehabilitation have been proposed to avoid (eliminate) or reduce these impacts. The environmental performance of the Proposal would manage through the implementation of the construction, operational and closure and rehabilitation environmental management plans and monitoring programs. This would also help to ensure compliance with relevant legislation and any conditions of approval.

21.3 Consideration of ecologically sustainable development

The principals of ecologically sustainable development include:

- **Integration**. Decision making processes should effectively integrate both long term and short term economic, social, environmental and equitable considerations.
- **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 and intra-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. Intra-generational equity involves consideration of equity within the present generation.
- **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.
- **Public participation**. Decisions and actions relating to ecologically sustainable development should provide for broad community involvement on issues which affect them.

An assessment of the Proposal against these principles is provided below.

21.3.1 Integration

Environmental impacts during both construction (short term), operation (long term) and closure and rehabilitation (short term) of the Proposal have been considered for each of the key environmental risks identified. The Proposal would provide both short term and long term benefits including a boost to the economy, job creation, provision of local training opportunities and indigenous employment and training opportunities. It would also provide local business support and create new business opportunities. The Proposal would also provide a national solution of the safe and secure disposal of waste generated in Australia, within Australia.

21.3.2 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 impacts, where possible, and to reflect the findings of the studies undertaken. For example, existing roads were chosen to be utilised for the proposed Chandler Haul Road and Henbury Access Road. A number of safeguards have also been proposed to minimise the potential environmental impacts. These safeguards would be implemented during construction, operation and during closure and rehabilitation of the Proposal. Both a CEMP, OEMP and RCP would be prepared prior to construction, operation and closure and rehabilitation of the Proposal.

21.3.3 Inter-generational and intra-generational equity

Construction, operation and closure and rehabilitation of the Proposal 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, OEMP and RCP would ensure there would be no significant impact that would diminish the health, diversity or productivity of the environment for present or future generations.

21.3.4 Conservation of biological diversity and ecological integrity

An ecological assessment has been undertaken to identify potential adverse effects on biodiversity. The study demonstrates that the Proposal would not have significant effect on any local populations of native biota including threatened and endangered species, populations or ecological communities listed under the TPWC Act and/or the EPBC Act.

21.3.5 Improved valuation, pricing and incentive mechanisms

The environmental 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, operation, and closure and rehabilitation of the Proposal would be in accordance with relevant legislation, the conditions of approval and the CEMP, OEMP and RCP. 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.

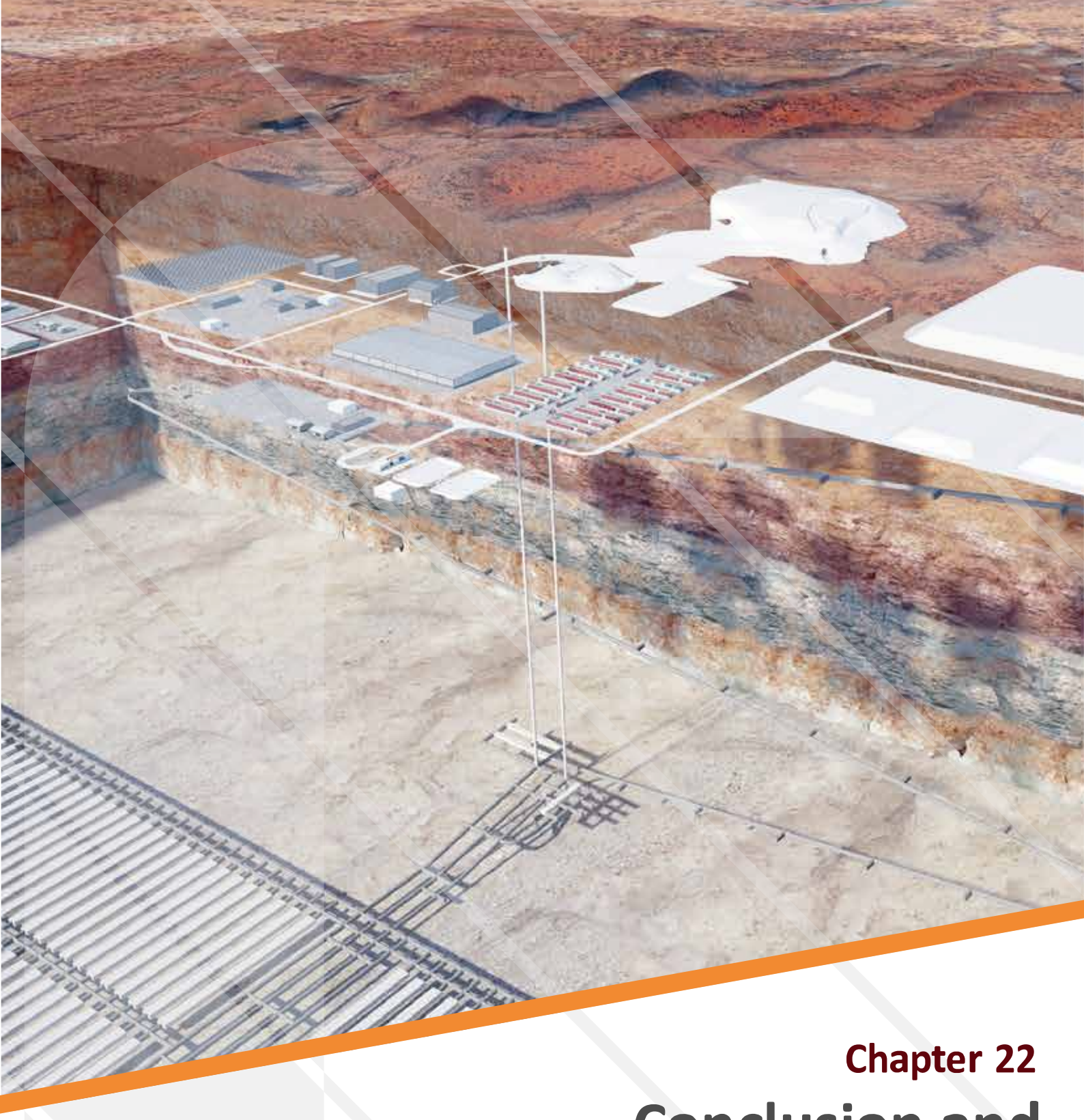
The concept design for the Proposal has been developed with an objective of minimising potential effects on the surrounding environment. This indicates that the concept design has been developed with consideration of environmental outcomes.

21.3.6 Public participation

Comprehensive government and community (including key stakeholder) consultation was undertaken during the development of the Proposal and during the preparation of the environmental impact assessment for the Proposal. The overall objective of the consultation process was to ensure clear, two-way communication by listening, recording and responding to issues as they arose. The specific objectives were to disseminate information about the Proposal and the assessment process to key stakeholders and the community; increase stakeholder and community awareness and understanding of the Proposal and the assessment process; ensure that key stakeholders and the community were provided with opportunities through the consultation process to communicate feedback and to identify issues so that they could be included in the Proposal; and to identify stakeholder and community issues and views.

Issues identified during the consultation process were included in the design of the Proposal or within the mitigation measures developed to safeguard the environment from potential impacts during construction and operation.

Consultation will continue throughout the exhibition of the draft EIS. During the exhibition period, government agencies, key stakeholders and the community will be invited to make written submissions to the NT EPA.



Chapter 22

Conclusion and Recommendations

This page has been left intentionally blank

22 CONCLUSION AND RECOMMENDATIONS

22.1 Conclusion

Tellus propose to construct and operate an underground rock salt mine and a complementary storage, recovery and permanent isolation facility (herein referred to as the 'Chandler Facility'). A rail siding and temporary storage and transfer facility that would be located adjacent to the Central Australian Railway (herein referred to as 'the Apirnta Facility') is also proposed. A private haul road linking the two facilities (herein referred to as the 'Chandler Haul Road') would be constructed. A private access road (herein referred to as 'Henbury Access Road') would be constructed to link the Apirnta Facility with the Stuart Highway. Collectively, the two proposed facilities and the haul and access roads are referred to as "the Proposal".

If approved, the Chandler Facility and Chandler Haul Road would be located within the Maryvale Station (NT Portion 810), approximately 120 kilometres south of Alice Springs and about 25 kilometres by road from the community of Titjikala. The Apirnta Facility, Henbury Access Road and a portion of the Chandler Haul Road would be located within Henbury Station (NT Portion 657), approximately 30 kilometres to the west of the Chandler Facility. This EIS has been prepared by the proponent to support the key approvals under both the EA Act and the EPBC Act for the construction and operation of the Proposal. This EIS has been prepared to address the requirements set out in the Terms of Reference issued by the NT EPA on 23 September, 2016 under the EA Act.

22.1.1 Salt business

According to the 2014 Salt Market Report by Roskill, salt has greater than 14,000 commercial applications globally. Approximately 80 % of salt is consumed across four main markets. These include Chloralkali production, synthetic soda ash production and road de-icing.

Challenges and opportunities in the salt market

Through desktop research, industry consultation, and domestic and international site visits, dry and wet salt pilot projects and marketing direct to buyers the proponent has developed a high level of understanding of both the international and domestic salt demand and supply forecasts. A summary of the current salt market situation, the challenges and opportunities in the salt market and how these challenges and opportunities relate to the Proposal is provided in Table 22-1.

Given the specification and quality of the proponent's salt within the Chandler Formation, the chlor-alkali industry in China, Japan and Indonesia are considered to present the greatest opportunity for the export of salt from the Proposal.

Table 222-1 Challenges and opportunities in the salt market

Current situation	Challenges and opportunities	Competitive advantage of the Proposal
• Asia consumes about 42 % of the global supply of salt. • Demand for salt is growing at 3-5 % per annum in Asia. • Australia is the largest external supplier of salt to Asia (about 60% of salt imported to Asia comes from Australia). However, Australia is near production capacity. • Australia produces approximately 13.2 million tonnes of salt per annum (M tpa) predominantly via solar evaporative salt facilities in Western Australia. • In Australia and Asia, salt is produced predominantly via solar evaporative salt facilities – heavy rain and cyclones can disrupt salt production in solar evaporative facilities for months at a time. • This process is also quite inefficient (about 65 tonnes of sea water is needed to produce one tonne of salt) and time intensive (the process can take between 12-18 months).	**Challenges** • There is growing concern by Asian salt buyers about reliable supply, quality and price pressure. • There is an approximate six million tonne shortfall of salt expected in the Asian market by 2018. • To meet this shortfall, up to 47,000 hectares of new solar evaporative salt facilities would be required along environmentally sensitive coastal areas. • It is becoming increasingly difficult to secure approvals for new solar evaporative salt projects in Australia due to their environmental impact. (three recent failed applications 2.5 M tpa, 3- 4 M tpa and approximately 1 M tpa). **Opportunities** • There are new markets in Asia and growing demand from existing markets, but growing supply pressures. • An opportunity exists to meet the growing demand for salt in Asia. This opportunity is mining of rock salt in the Chandler Formation in the NT. Currently, no deep rock salt mining exists in Australia.	• Unlike solar evaporative salt facilities which are located in environmentally sensitive coastal areas and, are becoming increasingly difficult to obtain planning approval for, the Proposal will have a relatively small surface footprint and is located in semi-arid zone not affected by cyclones, in a geographically and tectonically stable area. • Extensive investigations have proven that billions of tons of salt are contained within the Chandler Formation. • Mining this salt could easily be scaled up to meet demand. • Core testing shows high grade salt is available. • Existing logistics infrastructure is in place and has spare capacity. • The Adelaide/Darwin Railway Line is located adjacent to the proposed Apirnta Facility and would be used to transport salt from the proposed Chandler Facility to port facilities in Adelaide. • Australia is a gateway to Asia. We are closer than India and Chile who also supply salt to Asia.

22.1.2 Storage business

There is a need and regulatory obligation to provide for the safe and secure storage, recovery of valuable materials and the permanent isolation of hazardous waste. The solution put forward involves the storage (retrievable) and recovery of valuable materials and the permanent isolation of such wastes in a deep underground 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 waste that relies on both a natural geological barrier (e.g. a salt bed) and man-made engineered barriers that both form part of a multi barrier 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 repository 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 hazardous waste.

Waste hierarchy

There is a clear difference between what is considered best practice for hazardous and non-hazardous wastes. The 'waste hierarchy' methodology suggests the primary focus of waste management should be on reusing, recycling and recovering materials. This methodology is a broadly accepted policy for general (non-hazardous) wastes (refer to Figure ES-3).

A different framework is appropriate for hazardous wastes, which present a danger to health or the environment and, as such, should generally not be re-integrated into manufacturing processes for re-use. With these kinds of wastes, international best practice as reflected in conventions such *as the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal* ('The Basel Convention') adopt environmentally sound management principles, which focus on the permanent removal of such wastes from the biosphere, and in so doing protect the environment and human health.

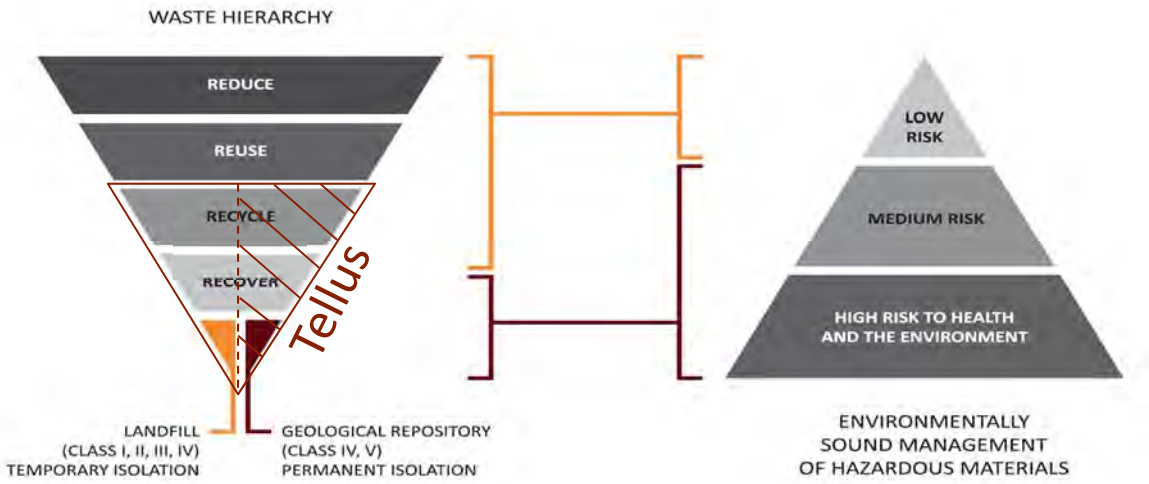


Plate 22-1 The waste hierarchy and the proponent's service offering

Circular economy

One of the advantages of geological repositories is that one can also support 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.

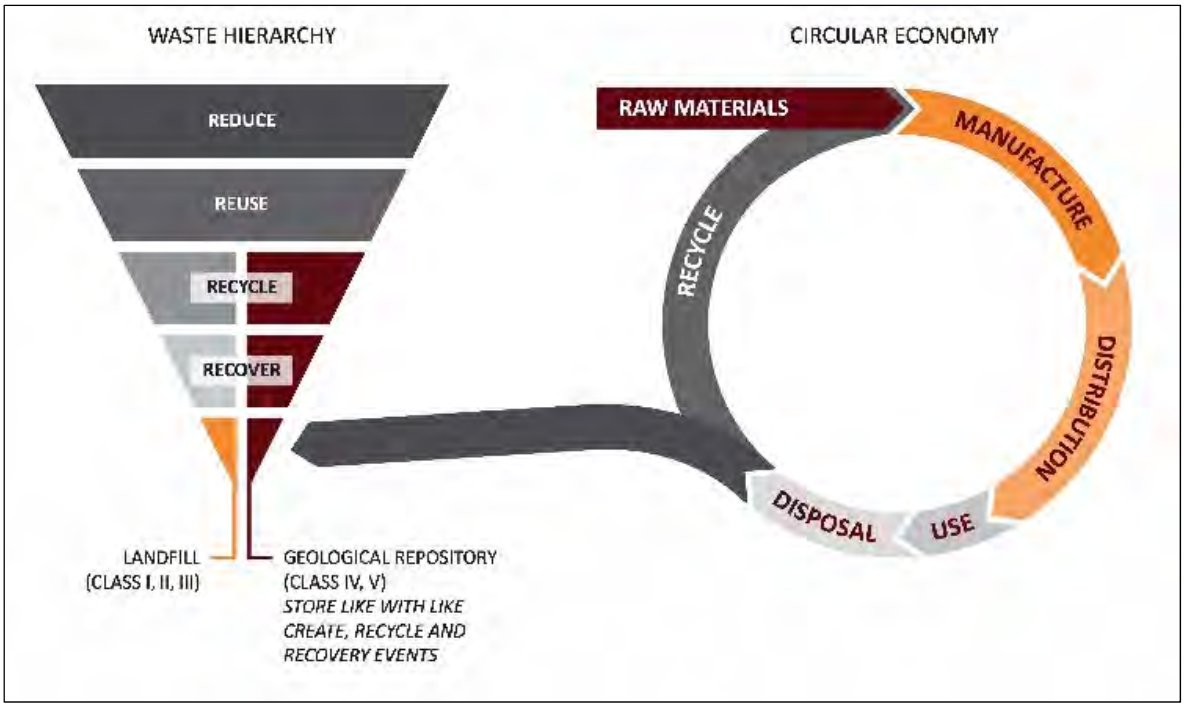


Plate 22-1 The proponent's business model supports the circular economy

Challenges and opportunities in the waste market

Through desktop research, industry consultation, and domestic and international site visits, salt pilot projects and marketing direct to buyers the proponent has developed a high level of understanding of both the design, construction, build and closure experience of mostly the European and North American facilities, plus domestic waste demand and supply forecasts. A summary of the current waste market situation, the challenges and opportunities in this market and how these challenges and opportunities relate to the Proposal is provided in Table 22-2.

Table 222-2 Challenges and opportunities in the waste market

Current situation	Challenges and opportunities	Competitive advantage of the Proposal
• **Australians are the second highest emitters of hazardous waste per capita**	**Challenges** • Waste production in Australia has grown at six times population growth.	• World's best practice • Tellus stores like with like • Tellus supports the circular economy = "Take, Make, Recover this Generation or

Current situation	Challenges and opportunities	Competitive advantage of the Proposal
• **Resources and energy boom translates to a waste boom.** • **Manufacturing decline generates a contaminated soil waste boom.** • **Market size: 6 M tpa and growing at 3% per year.** • **Large legacy waste pool (900 M t) due to lack of affordable supply and growing.** • **Increased regulation and environmental legislation.** • **Directors assume personal liabilities and this regime is now being extended further to certain employees.** • **Landfill liner useful life before isolation properties are compromised is 10-30 years, yet >50% still accept hazardous waste.** • **Traditional re-processing, incineration, treatment before landfilling, storage/disposal into man-made engineered landfill are temporary solutions.** • **There are limited cost effective solutions available**	• Australian and international accounting standards are now exposing the size of waste problem. • Complex technical solutions, long lead times for viable solutions and costly alternatives are frustrating producers. • Legislation increasingly banning surface landfills. • Lack of transparency in pricing from existing players. • Transportation costs. • Complex regulatory issues. • Final disposal of mixed wastes types supports the linear economy "Take, Make and Dispose". **Opportunities** • Waste market is a $14.5 billion industry that hires over 50,000 people and is growing. • No salt geological repository businesses exist in Australia.	Store Safely for next Generation or Dispose Safely". • Permanent isolation of hazardous materials using sound environmental management principals. • Cost advantage • Model removes company, Director and employee liability • Simplicity and flexibility • One of the few tools that can solve the large legacy waste problems • Tellus' solutions could be key tools for governments in emergency situations (mn made and natural disasters) •

Benefits

Proceeding with the Proposal would result in significant social and economic benefits in the NT and within Australia. The Proposal would:

- Provide an innovative unique dual revenue business in remote Central Australia.
- Diversify the economy.
- Major investment in regional Australia Boost the economy over the 29-year project life.
- Royalties, taxes and levies.

- Create training and long term job opportunities.
- Provide local business support and new business opportunities.
- Fulfil the government's own environmental and waste policy obligations under the following four main regulatory regimes.
- Support the circular economy.

Environmental impact

Environmental investigations were undertaken to assess the potential effects 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 minor adverse impacts on the environment.
- These impacts would be managed and mitigated by implementing the various mitigation measures outlined in this EIS and by adhering to relevant legislation, regulations, policies and guidelines.
- The environmental performance of the Proposal would be managed through the implementation of the construction, operational, and closure and rehabilitation environmental management plans. This would also help to ensure compliance with relevant legislation, regulation and any conditions of approval.

It is considered that the Proposal is justified on the basis of environmental acceptability and is in accordance with the principles of ecologically sustainable development.

Based on this environmental impact assessment, it is considered that the long term operational benefits of the Proposal would outweigh the minor adverse effects of the Proposal.

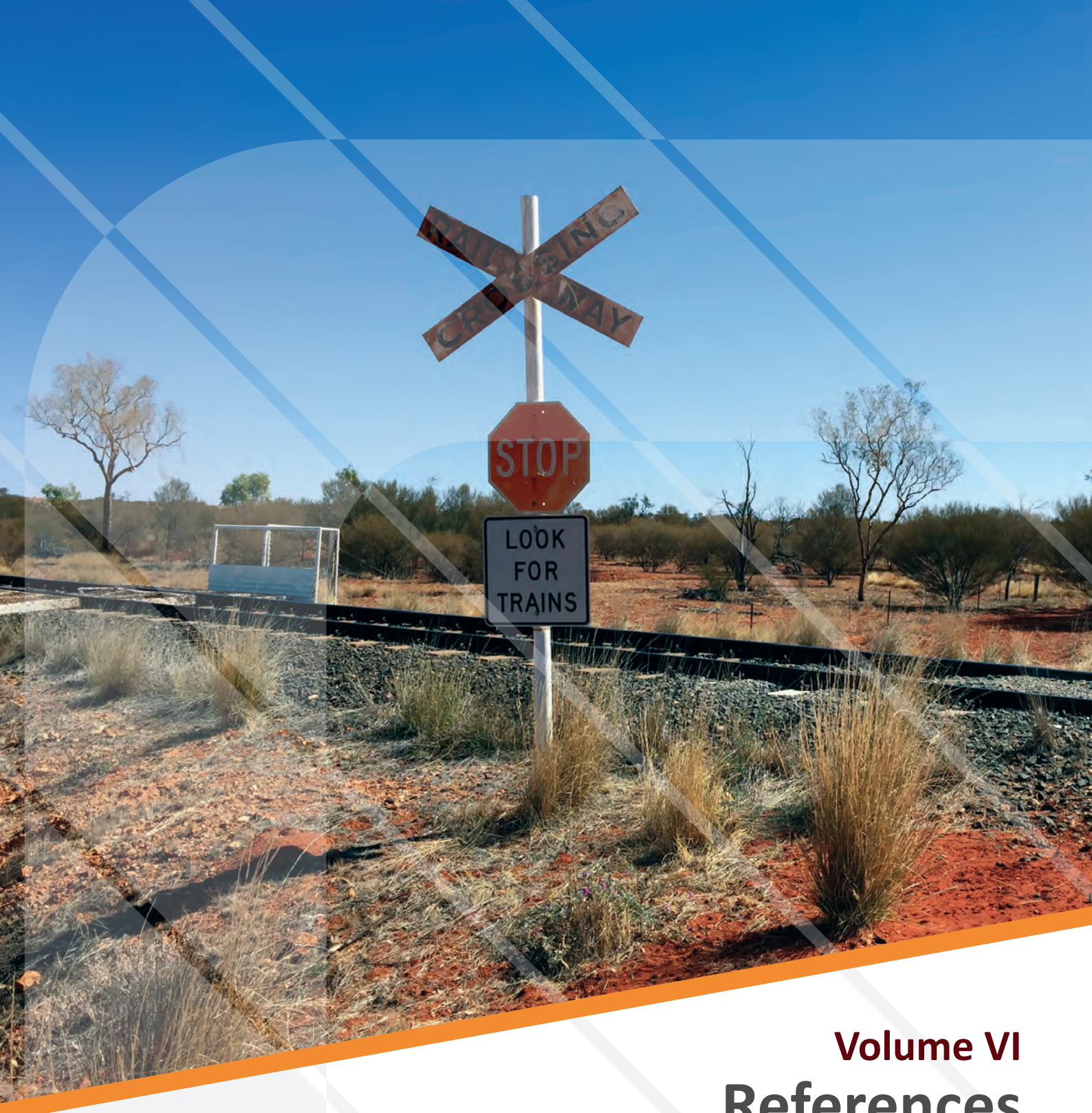
22.2 Recommendations

It is recommended that the Proposal be approved under Part 3 Sections 18, 18A, 20 and 20A of the *Environment Protection Biodiversity Conservation Act 1999,* and under the NT *Environmental Assessment Act* for the following reasons:

- It would not result in significant adverse environmental impacts on matters of National Environmental Significance under the EPBC Act and associated Regulations.
- It would not result in adverse impacts on human health.
- Appropriate engineering design and strict environmental on-site management (through both a construction and operational environmental management plan) would be followed to avoid the potential environmental impacts and adverse human health effects identified in this EIS.

- It would provide an innovative unique dual revenue business in remote Central Australia that should result in significant long term environmental, social and economic and benefits:
    - Environmental benefits include the safe and secure storage, recovery and permanent isolation of hazardous waste, support for the circular economy through the recovery of valuable materials and the fulfilment of the government's own environmental and waste policy obligations.
    - Social benefits include local and indigenous long term employment and training opportunities.

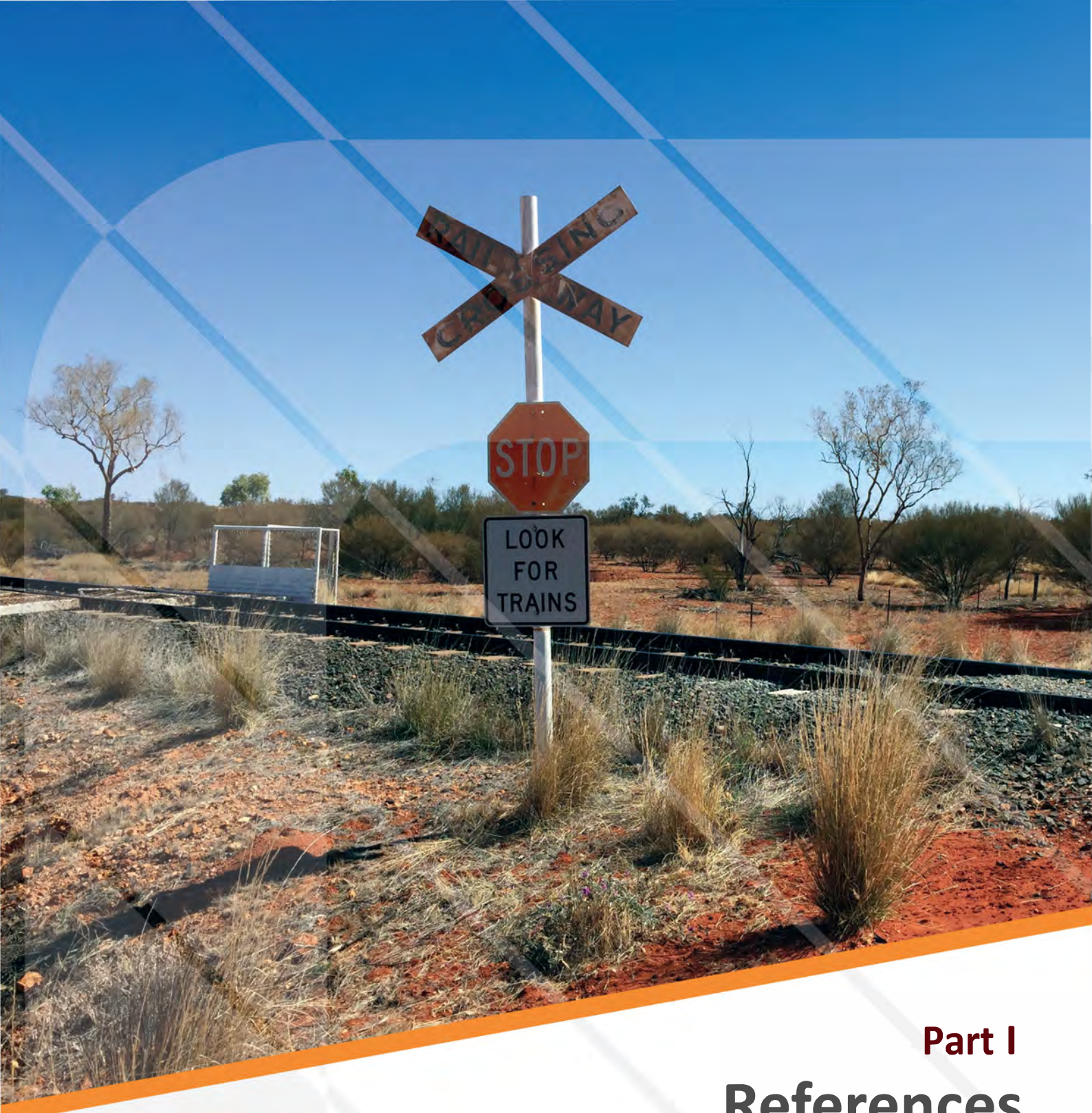
Economic benefits include a long term boost to the local economy, the creation of material local business prospects, royalties, taxes and levies.



Volume VI

References

TELLUS



Part I

References

TELLUS



Chapter 23
References

This page has been left intentionally blank

23 REFERENCES

A

ABC, 2014), 'Desert community enjoys rainy respite'. Access online at: http://www.abc.net.au/local/stories/2014/04/09/3981714.htm

ABS, 2011, 'The Census of Population and Housing 2011'. Australian Bureau of Statistics.

ABS, 2013, 'Waste Account, Australia, Experimental Estimates, 2013'. Australian Bureau of Statistics.

ABS, 2016, 'Cat 4655.0 - Australian Environmental-Economic Accounts, April 2016'. Australian Bureau of Statistics.

Alley, N. F., and Gravestock, D. I., 1995, 'Middle Palaeozoic (Devonian)'. The Geology of South Australia, 54, 43-45.

ANZECC and ARMCANZ, 2000, 'Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000'. National Water Quality Management Strategy, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

Ashton, L. and McKenzie, N., 2001, 'Conversion of the Atlas of Australian Soils to the Australian Soil Classification (ASC)'. CSIRO Land and Water (unpublished).

Atkins, 2016, 'Preliminary Assessment of the Salt Horizon Geomechanics of Chandler Salt Mine'.

Australian Government Bureau of Meteorology (BoM), 2016, 'Climate statistics for Alice Springs Airport'. Access online at: http://www.bom.gov.au/climate/averages/tables/cw_015590_All.shtml

Australia International Council on Monuments and Sites (ICOMOS), 1987, 'Australia ICOMOS Charter for the Conservation of Places of Cultural Significance'.

Australian Government National Water Commission, 2012, 'Minimum Construction Requirements for Water Bores in Australia, Third Edition'.

Australian Government National Water Commission, 2012, 'Australian Groundwater Modelling Guidelines'.

Australian Radiation Protection and Nuclear Safety Agency, 2002, 'Expectations Guideline 13 November 2002 Volume 3'.

Australian National University (ANU), 2016, 'Australia's Environment in 2015'. Access online at: http://www.wenfo.org/wald/australias-environment/

Australian Weed Strategy, 2005, 'Australian Weeds Strategy – A National Approach for Weed Management in Australia'.

B

Beca, 2016, 'Hydrology Technical Assessment'. A report commissioned by Tellus Holdings.

Benshemesh, J., 2005, 'Manual for Marsupial Mole Survey and Monitoring by Trenches, Version 1.0'. Report to Anangu-Pitjantjatjara Land Management and the Department of Heritage and Environment (SA).

Blue Environment Pty Ltd, 2015, 'Hazardous Waste Infrastructure Needs and Capacity Assessment'.

Brierley G. J. and Fryirs K. A., 2005, 'Geomorphology and River Management. Application of the River Styles Framework'. Blackwell Publishing.

Bunn S, Thoms M, Hamilton S and Capon S, 2006, 'Flow variability in dryland rivers: boom, bust and the bits in between'. River Research and Applications, **22**, 179-186.

C

Carroll, B. and Turpin, T., 2009, 'Environmental Impact Assessment Handbook. 1st ed'. London: Thomas Telford.

Central Land Council, 2016, 'Submission to the Housing Strategy Consultation Draft'.

Churchill, S., 2008, 'Australian Bats., 2nd ed'. Allen and Unwin: Sydney.

Clean Energy Regulator, 2015, 'About the Emissions Reduction Fund'. Accessed at: http://www.cleanenergyregulator.gov.au/ERF/About-the-Emissions-Reduction-Fund

Cook, P. J., 1968, 'Henbury Northern Territory 1:250 000 geological series explanatory notes. Sheet SG53-1'. Bureau of Mineral Resources, Australia 19pp.

Costantini, A., Loch, R. J., Connolly, R. D. and Garthe, R., 1999, 'Sediment Generation from Forest Roads: Bed and Eroded Sediment Size Distributions, and Runoff Management Strategies'. Australian Journal of Soil Research, 37(5), pp. 947-964.

D

DeStafano, S., Schmidt, S. L. and deVos, J. C., 2000, 'Observations of Predator Activity at Wildlife Water Developments in Southern Arizona'. Journal of Range Management, Volume 53, pp. 255-258.

Department of Environment, 2013, 'Significant Impact Guidelines 1.1-Matters of National Environmental Significance'.

Department of the Environment, 2015, 'Emissions Reduction Fund. Making Determination Guidelines'.

Department of Environment, 2015, 'National Greenhouse Accounts Factors, Australian National Greenhouse Accounts, August 2015'.

Department of Infrastructure and Regional Development (DoIRD), 2003, 'Federal Government Bridges the Finke River'. Accessed at: https://infrastructure.gov.au/department/statements/2003_2004/media/a9.aspx

Department of Land Resource Management (DLRM), 2013, 'Native Vegetation Buffers and Corridors. In Vegetation Management in the Northern Territory Fact Sheet'. Created March 2013 and updated January 2016.

Department of Environment (DoE), 1998, 'Levels of heavy metals in the sediments of Queensland rivers, estuaries and coastal waters'. Brisbane. ISSN: 1037-4671.

Department of the Envionment and Energy, 2016, 'National Greenhouse and Energy Reporting (Measurement) Determination 2008'. Accessed at: https://www.environment.gov.au/climate-change/greenhouse-gas-measurement/nger/determination

Department of the Environment and Natural Resources, 2016, 'Bushfires ACT NT'. Accessed at: https://landresources.nt.gov.au/bushfires/bushfires-act-nt

Department of the Environment, Water, Heritage, and the Arts, 2010a, 'Survey Guidelines for Australia's Threatened Mammals'.

Department of the Environment, Water, Heritage and the Arts, 2010b, 'Survey Guidelines for Australia's Threatened Birds'.

Department of Sustainability, Environment, Water, Population and Communities, 2011, 'Survey Guidelines for Australia's Threatened Reptiles'.

Department of Sustainability, Environment, Water, Population and Communities, 2012a, 'Australia's Bioregions (IBRA)'. Accessed at: http://www.environment.gov.au/parks/nrs/science/bioregion-framework/ibra/index.html

Department of Sustainability, Environment, Water, Population and Communities, 2012b, 'Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy'.

Dickman, C. R., 2001, 'Population dynamics of three species of dasyurid marsupials in arid central Australia: a 10-year study'. Wildlife Research, Volume 28, pp. 493-506.

Dilshad, M., 2007, 'A preliminary assessment of hillslope (sheet and rill) erosion and associated suspended sediment movement in the Daly River catchment, Northern Territory, Australia'. Northern Territory Department of Natural Resources, Conservation and the Arts, Report No. 18/2008D, Palmerston, NT.

Donaldson, A. and Bennet, A., 2004, 'Ecological Effects of Roads: Implications for the Internal Fragmentation of Australian Parks and Reserves'. Parks Victoria.

Duguid, A., 2011, 'Wetlands of the Great Artesian Basin Water Control District (Northern Territory). Technical Report No. 13/2011A'. Northern Territory Government Department of Natural Resources, Environment, the Arts and Sport. Alice Springs.

E

Elinor Alexander Petroleum Group, 1999, 'COOPER BASIN EXPLORATION OPPORTUNITY – SECOND ROUND BLOCKS CO99-A to H'. Accessed at: http://www.petroleum.statedevelopment.sa.gov.au/__data/assets/pdf_file/0003/239736/cooper_99.pdf

EMM Consulting, 2016, 'Chandler Facility Groundwater Assessment'.

Environmental Health Program Directorate Territory Health Services, 2014, 'Code of Practice for On-site Wastewater Management'.

ERCOSPLAN, 2014, 'Technical Report: Chandler Salt Mine Project, Central Australia'.

Erskine W. D, Saynor M. J, Evans K. J, Boggs G. S, 2001, 'Geomorphic research to determine the off-site impacts of Jabiluka Mine on Swift (Ngarradj) Creek, Northern Territory'.

Evans D. J, Gibson C. E and Rossell R. S., 2006, 'Sediment Loads and Sources in Heavily Modified Irish Catchments: A Move Towards Informed Management Strategies', Geomorphology, 79, 93-113.

F

Fahrig L., 2003, 'Effects of habitat fragmentation on biodiversity'. Annual Review of Ecology, Evolution and Systematics, Volume 34, pp. 487-515.

Ferdowsian, R., and McCarron, C, 2001, 'Hartt Manual; Hydrograph Analysis: Rainfall and Time Trends'. Department of Agriculture Western Australia. Perth, Western Australia.

G

Geoscience Australia, 2005, 'National Dynamic Landcover Dataset'. Accessed at: http://www.ga.gov.au/scientific-topics/earth-obs/landcover

Geoscience Australia, 2016, 'Water Observations from Space'. Accessed at: http://www.ga.gov.au/scientific-topics/hazards/flood/wofs/about-wofs

Gregory, R., 1988, 'Aboriginal Settlement Patterns in the Ord-Victoria River Region'. Unpublished PhD Thesis, Northern Territory University, Darwin.

Giuliano MF, 1988, 'The Geology and Hydrocarbon Potential of the Pedirka Basin'. BSc Hons Thesis, University of Adelaide, South Australia.

Guerschman J. P, Warren G., Byrne, G., Lymburner L., Mueller N., Van Dijk A. I. J. M., 2011, 'MODIS-based standing water detection for flood and large reservoir mapping: algorithm development and applications for the Australian continent'. CSIRO: Water for a Healthy Country National Research Flagship Report, Canberra.

H

Harford A., Simpson S., Chariton A., Humphrey C., Kumar A., Stauber A., van Dam R., 2013, 'Derivation of a sediment quality guideline for uranium'. Presented at SETAC Australasia, Melbourne, 1–3 October 2013. Copyright 2013 Department of Sustainability, Environment, Water, Population and Communities and CSIRO.

Hiscock P, 1984, 'A Preliminary Report on the Stone Artefacts from Colless Creek Cave, Northwest Queensland'. Queensland Archaeological Research 1:120-151.

Hiscock P., 1988, 'Prehistoric Settlement Patterns and Artefact Manufacture at Lawn Hill, Northwest Queensland'. Unpublished thesis, University of Queensland.

Hiscock P. and Attenbrow V., 1996, 'Backed into a Corner'. Australian Archaeology 42:64-65.

Hiscock P. and Mitchell S., 1993, 'Stone Artefact Quarries and Reduction Sites in Australia: Towards a Type Profile'. Australian Heritage Commission.

Hiscock P., and Veth P., 1991, 'Change in the Australian Desert Culture: A Reanalysis of Tulas Puntutjarpa Rockshelter'. World Archaeology 22:332-45.

Holdaway, S and Stern, N, 2004, 'A Record in Stone: The Study of Australia's Flaked Stone Artefacts'. Museum of Victoria and AIATSIS.

I

IEMA, 2008, 'Practitioner Vol 12: Environmental management plans'. Published by IEMA.

International Association for Public Participation, 2014, 'Public Participation Spectrum'.

International Association for Public Participation, 2016, 'Core Values'.

Isbell, R. and National Committee on Soil and Terrain, 2016, 'The Australian Soil Classificatoin 2nd ed'. CSIRO.

J

JNC, 2000, 'H12: Project to establish the scientific and technical basis for HLW disposal in Japan, Project Overview Report, Second Progress Report on research and development for the geological disposal of HLW in Japan', JNC TN1410 2000-001, Japan Nuclear Cycle Development Institute (now Japan Atomic Energy Agency).

Jolly P., Chin D., Prowse G. and Jamieson M. ,1994, 'Hydrogeology of the Roe Creek Borefield'. Water Resources Branch, Alice Springs.

Jolly, P., Knapton, A., Read R., Paul R. and Wischusen J., 2005. 'Volume of Groundwater Stored in the Mereenie Aquifer System, in Pine Gap/ Roe Creek to Rocky Hill / Ooraminna Region'. Northern Territory Department of Natural Resources, Environment and the Arts, Report WRA05036.

K

KMH Environmental, 2013, 'Hazardous Waste Data Assessment'. Accessed at: https://www.environment.gov.au/system/files/resources/ca7c7c3b-4061-4253-bea2-2352883c8677/files/hazardous-waste-data.pdf

L

Land Development Corporation, 2012, 'Land Development Corporation Development Guidelines Version 2 – June 2012'.

Landscape Institute, IEMA, 2013, 'Guidelines for Landscape and Visual Impact Assessment'. Third Edition, Publisher Taylor and Francis.

Lloyd J. W. and Jacobson G., 1987, 'The Hydrogeology of the Amadeus Basin, Central Australia'. Journal of Hydrology, 93, 1-24.

Local Government Association of the NT (LGANT), 2016, 'LGANT Newsletter'. Accessed at: http://www.lgant.asn.au/download/lgant-newsletter/2016-01-19-LGANT-News-PDF.pdf.

Love A. J, Wohling D., Fulton S., Rousseau-Gueutin P and De Ritter S., 2013, 'Allocating Water and Maintaining Springs in the Great Artesian Basin', Volume II: Groundwater Recharge, Hydrodynamics and Hydrochemistry of the Western Great Artesian Basin, National Water Commission, Canberra.

Low Ecological Services, 2013, 'Soils Investigation Report'. A report commissioned by Tellus Holdings, October 2013.

M

MacQueen A. D. and Knott G. G., 1982, 'Groundwater in the North Eastern part of the Amadeus Basin'. Department of Transport and Works, Water Division.

May S. A. and Norton T. W., 1996, 'Influence of Fragmentation and Disturbance on the Potential Impact of Feral Predators on Native Fauna in Australian Forest Ecosystems. Wildlife Research, Volume 23, pp. 387-400'.

Maquis-Kyle P. and Walker M., 1992, 'The Illustrated Burra Charter: Making Good Decisions about the Care and Important Places'. Australian Heritage Commission, Canberra.

McCarthy F. D, 1976, 'Australian Aboriginal Stone Implements'. The Australian Museum Trust, Canberra.

McDonald P., 2012, 'Threatened Species of the Northern Territory - Slater's Skink *Liopholis slateri*'. NT Department of Land Resource Management.

Miles C., Keppel M., Fulton S., Osti A. and Foulkes J., 2015, 'Context statement for the Pedirka subregion. Product 1.1 for the Pedirka subregion from the Lake Eyre Basin Bioregional Assessment'. Department of the Environment, Bureau of Meteorology, CSIRO, Geoscience Australia and Government of South Australia, Australia.

Monroe M., 2008, 'Australia: The Land Where Time Began - Anabranching Rivers'. Accessed at: http://austhrutime.com/anabranching_rivers.htm

Munson T. J., Ahmad M. and Dunster J. N., 2013, 'Geology and mineral resources of the Northern Territory'. Northern Territory Geological Survey, Special Publication 5.

N

Nanson C., and Knighton D., 1996, 'Anabranching Rivers: their cause, character and classification'. Earth Surface Processes and Landforms, 219-239.

National Health and Medical Research Council in collaboration with the Natural Resource Management Ministerial Council, 2011, 'Australian Drinking Water Guidelines (2011) – Updated February 2016'.

Neave H. and Natural Heritage Trust (Australia), 2004, 'A resource assessment towards a conservation strategy for the Finke bioregion, Alice Springs'.

North Australia and Rangelands Fire Information, 2016, 'Fire Maps'. Accessed at: www.firenorth.org.au

Northcote K. H. with Beckmann G. G., Bettenay E., Churchward H. M., Van Dijk D. C., Dimmock G. M., Hubble G. D., Isbell R. F., McArthur W. M., Murtha G. G., Nicolls K. D., Paton T. R., Thompson C. H., Webb A. A. and Wright M. J., 1960-1968, 'Atlas of Australian Soils'. CSIRO and Melbourne University Press.

NT Department of Health – Environmental Health, 2014a, 'Environmental Fact Sheet No. 700: Requirements for Mining and Construction Projects'.

NT Department of Health – Environmental Health, 2014b, 'Public and Environmental Health Guidelines for Public Accommodation'.

NT Environment Protection Authority, 2013a, 'Guidelines for Assessment of Impacts on Terrestrial Biodiversity'.

NT Environment Protection Authority, 2013b, 'Guidelines on Environmental Offsets and Associated Approval Conditions'.

NT Environment Protection Authority, 2013c, 'Standard Terrestrial Vertebrate Survey Methods used by the DLRM'.

NT Environment Protection Authority, 2013d, 'Guidelines for the Preparation of an Economic and Social Impact Assessment.'

NT Environment Protection Authority, 2013e, 'Guidelines for the Siting, Design and Management of Solid Waste Disposal Sites'.

NT Environment Protection Authority, 2013f, 'Guidelines on Mixing Zones Version 1.2'.

NT Environment Protection Authority, 2013g, 'Noise guidelines for development sites in the Northern Territory'.

NT Environment Protection Authority, 2015, 'Waste Management Strategy for the Northern Territory 2015-2022'.

NT Government, 2016, 'Water Data Portal'. Accessed at: www.nt.gov.au/environment/water/water-data-portal

NT Government, 2015, 'Northern Territory Population Projections Summary'. Darwin: NT Government.

NT Shelter, 2016, 'NT Shelter Factsheets – Ten Year Housing Affordability Report Card'. Darwin: NT Shelter.

NT Treasury, 2015, 'NT Budget 2015/16: Northern Territory Economic Overview'. Darwin: NT Government.

NT Government, 2012, 'Great Artesian Basin Resource Assessment'. Report 14/2012A, Department of Land Resource Management.

P

Parendes, L. A. and Jones, J. A., 2000, Role of Light Availability and Dispersal Mechanisms in Invasion of Exotic Plants Roads and Streams in the H. J. Andrews Experimental Forest, Oregon. Conservation Biology., Volume 14, pp. 64-75'.

Pavey, C., 2011, 'Habitat Use, Population Dynamics and Species Identification of Mulgara, *Dasycercus blythi* and *D. cristicauda*, in a Zone of Sympatry in Central Australia'. Australian Journal of Zoology, Volume 59, pp. 156-169.

Pavey C., 2015, 'Threatened Species of the Northern Territory, Southern Marsupial Mole Itjaritjari Notoryctestyphlops'. Accessed at: https://nt.gov.au/__data/assets/pdf_file/0016/205522/southern-marsupial-mole.pdf

Perry R. A., Mahbbutt J. N., Litchfield W. H. and Quinlan T., 1960, 'Land Systems of the Alice Springs Area, Northern Territory, Australia: CSIRO Land Research Series No. 6'.

Q

Quintessa, 2016, 'Chandler Facility Risk Assessment: Operational Phase Risk Assessment'.

R

Read R.E. and Paul R. J., 2002, 'Rocky Hill –Ooraminna Groundwater Investigation 2000, Report No. 05/2000' NT Government Department of Infrastructure, Planning and Environment, Natural Resources Division, Alice Springs.

Real Estate Institute of Northern Territory Inc., 2016, 'The Northern Territory Real Estate Local Market Report: December Quarter 2015'. Darwin: Real Estate Institute of Northern Territory Inc.

Ride Consulting, 2016, 'Annual Hydrostation Inspection Report'. Tellus Chandler Salt Mine Project. Hydrographic Stations. April 2016.

Robson B. ,2008, 'Managing Flows for Ephemeral Streams Fact Sheet 2'.

Roskill, 2014, 'Salt: Global Industry Markets and Outlook' Fourteenth Edition, 54 Russell Road, London SW19 1QL UK 54 Russell Road, London SW19 1QL UK.

Rowden P. J., Steinhardt D. A. and Sheehan M. C., 2008, 'Road Crashes Involving Animals in Australia'. Accident Analysis and Prevention, 44(6), pp. 1865-1871.

RPS Group, 2013, '2013 Chandler 2D Seismic Interpretation Report'.

RPS Group, 2012, 'Chandler Seismic Review'.

S

Sheldon F. and Fellows C. S., 2010, 'Water quality in two Australian dryland rivers: Spatial and temporal variability and the role of flow'. Marine and Freshwater Research, 61(8).

Simpson S. L., Batley G. B. and Chariton A. A., 2013, 'Revision of the ANZECC/ARMCANZ Sediment Quality Guidelines. CSIRO Land and Water Science Report 08/07'. CSIRO Land and Water.

Smith M. A., 2006. Characterizing Late Pleistocene and Holocene stone artefact assemblages from Puritjarra rock shelter: a long sequence from the Australian Desert. Records of the Australian Museum 58(3): 371–410'.

Smith S. and Hill J., 2011, 'Supporting Sustainable Development – Risks and Impacts of Plant Industries on Soil Condition'. Northern Territory Government, Australia. Technical Bulletin No. 340.

Strahler A. N., 1957, 'Quantitative analysis of watershed geomorphology', Transactions of the American Geophysical Union 38 (6): 913–920.

Sullivan M. E. and Bowdler S. (eds), 1984, 'Site Surveys and Significance Assessment in Australian Archaeology'. Australian National University, Canberra.

T

Taylor N. C. and Goodrich C., 2011, 'Social Capital, resilience and livelihoods: core concepts for understanding community adaptation to social impacts'. Paper presented at the International Association for Impact Assessment (IAIA) annual meeting at Puebla, Mexico, 28 May-4 June 2011.

Thompson J. R., Taylor M. P., Fryirs K. A. and Brierley G. J., 2001, 'A geomorphological framework for river characterization and habitat assessment'. Aquatic Conservation: Marine and Freshwater Ecosystems, No. 11, pp. 373 – 389.

Thomson J., Taylor M. and Brierley G., 2004, 'Are River Styles® ecologically meaningful? A test of the ecological significance of a geomorphic river characterization scheme'. Aquatic Conservation – Marine and Freshwater Ecosystems, 14: 25-48.

Thorley P., 1988, 'Shifting Location, Shifting Scale: A Regional Landscape Approach to the Prehistoric Archaeology of the Palmer River Catchment, Central Australia'. Unpublished PhD Thesis, Northern Territory University, Darwin.

Todd D. K., and Mays, L. W., 2005, 'Groundwater Hydrology '. NY: John Wiley & Sons.

Turner, G. F., 2013, 'Vulnerability of Vegetation to Mining Dust at the Jack Hills, Western Australia'. The Unversity of Western Australia.

U

URS, 2012, 'Groundwater recharge. Section 4.7.4 of Geology, Hydrology and Hydrogeology Report. Chandler Salt Mine Project Pre-Feasibility Study'.

V

Vanclay F., 2003, 'International principles for social impact assessment. Impact assessment and project appraisal, 21(1), 5-12'.

Vanclay F., Esteves A. M., Aucamp I. and Franks D. M., 2015, 'Social Impact Assessment: Guidance for assessing and managing the social impacts of projects'.

W

WasteNet, 2016, 'Waste'. Available at: http://www.wastenet.net.au/state-definitions.aspx

Watling, K., 2007, 'Measuring salinity. Queensland Natural Resources and Water L, 137'.

Wells D. L., and Coppersmith K. J., 1994, ‘New empirical relationships among magnitude, rupture length, rupture width, rupture area, and surface displacement’. Bulletin of the seismological Society of America, 84(4), 974-1002.

Wells A. T., Forman D. J., Ranford L. C. and Cook P. J., 1970, ‘Geology of the Amadeux basin, central Australia (p. 100)’. Bureau of Mineral Resources Geology & Geophysics.

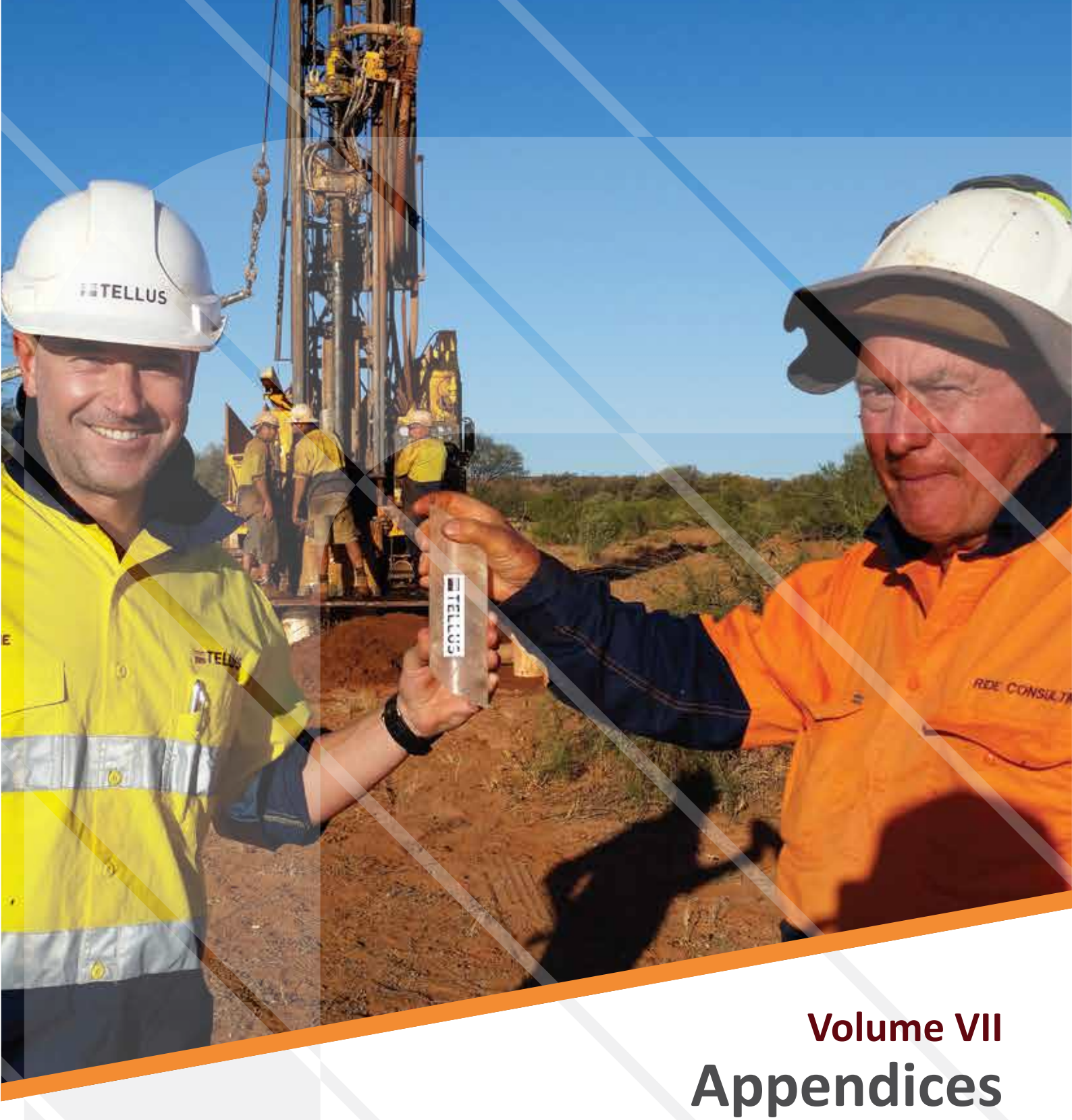
Whelan P., 2010, ‘Common Mosquitoes of the Northern Territory’. Department of Health and Families, Northern Territory Government.

Williams and Biggs, 2010, ‘Formation of Clay Pans in South-West Queensland, Australia’. 19th World Congress of Soil Science, Soil Solutions for a Changing World. 1 – 6 August 2010, Brisbane, Australia.

Wilson B. A. and Brocklehurst P. S., 1990, ‘Vegetation Survey of the Northern Territory: Notes to Accompany 1:100. 000 Map Sheets’. Northern Territory Conservation Commission.

Y

Yesertener C., 2007, ‘Assessment of the declining groundwater levels in the Gnangara groundwater mound, Western Australia. Hydrogeological Record Series HG14’.



Volume VII

Appendices

TELLUS