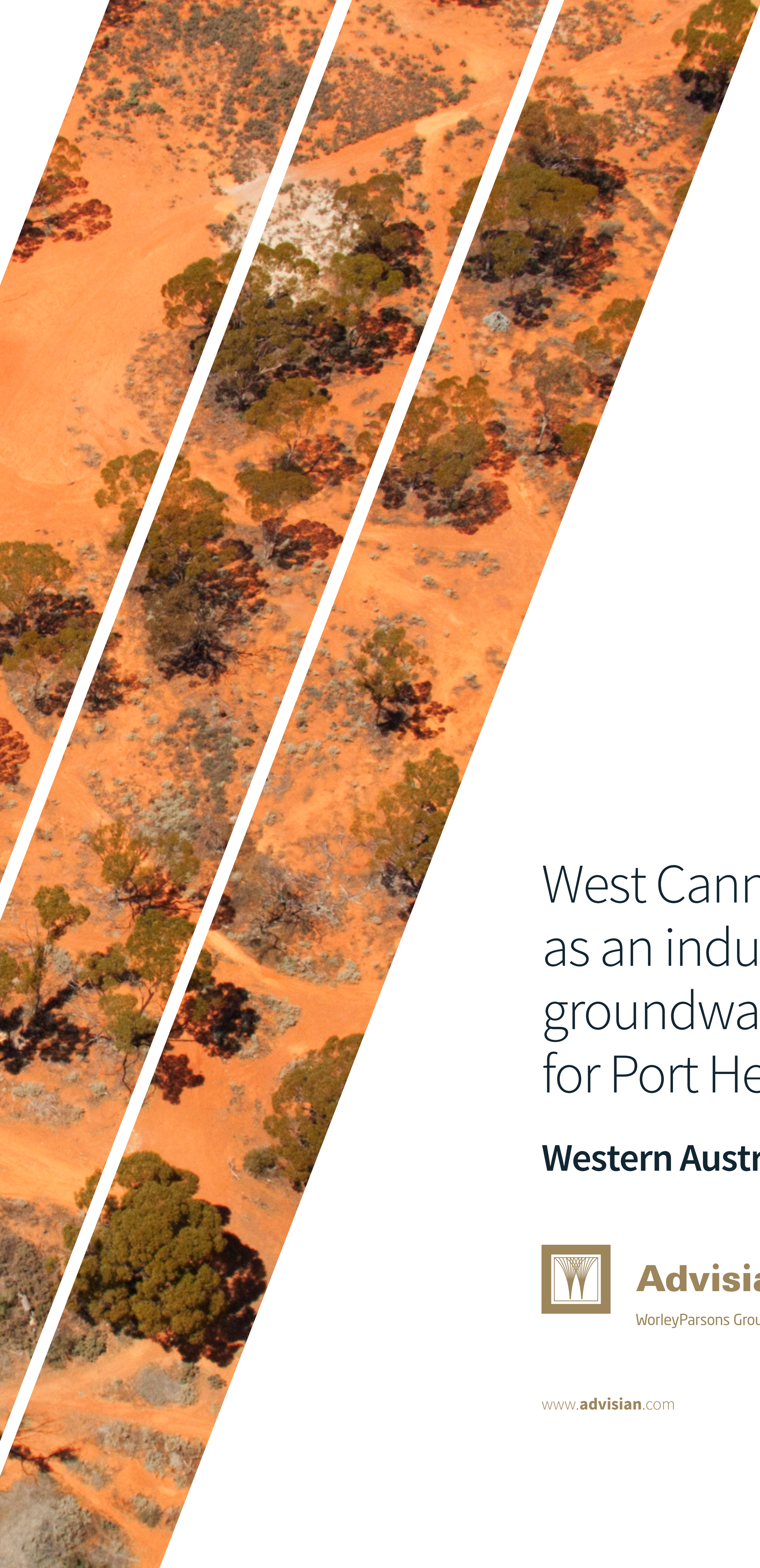

West Canning Basin as an industrial quality groundwater source for Port Hedland

Western Australia

Advisian
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Abstract

The Water Corporation of Western Australia commissioned a hydrogeological study which examined potential target areas in the West Canning Basin (WCB) in Western Australia, to supply up to 10 gigalitres/annum (GL/a) for industrial use in Port Hedland. The hydrogeological investigation included field assessment and groundwater modelling. Five target locations were identified, and test production and associated monitoring wells were drilled. An additional drilling program was undertaken to characterise the stratigraphy and assess potential recharge areas. The purpose of the revised field program was to confirm the existing conceptual model for the study area, in order to provide greater certainty for a potentially major capital investment to develop a well field in the area.

The study results led to a revised hydrogeological conceptualisation and based on the hydraulic gradient and isotopic data, recharge appears to be from the south-east of the WCB. The recharge mechanism remains unclear as to whether there is leakage from a regional river system in the south-east and/or surficial recharge where the Wallal aquifer is unconfined in the greater Canning Basin. Groundwater modelling, using the field derived aquifer hydraulic parameters and layer geometry, predicted well field drawdowns. These were used to assess the relative impacts on other users, the environment, groundwater dependent ecosystems (GDEs) and potential seawater intrusion of three proposed well field locations.

Introduction

Investigation of groundwater resources in the WCB (Figure 1) began in the 1970s when an estimated 50 GL/a groundwater resource was identified by the Geological Survey of Western Australia (Leech; in GSWA, 1979). The Wallal Sandstone aquifer is a predominantly confined aquifer that was assessed to have a large storage and superior water quality (acceptable for potable supply) compared with the unconfined aquifers of the region. There are constraints to groundwater development within the WCB, including the distance from Port Hedland, potential impacts on existing users, social and heritage values as well as GDEs that may be supported by the artesian heads of the Wallal aquifer.

The objective of this study was to verify potential water supply target areas capable of supplying up to 10 GL/a of non-potable water for ‘fit-for-purpose’ industrial use in Port Hedland. The salinity threshold value for industrial use adopted in the study was 1,200 mg/L of Total Dissolved Solids (TDS).

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Methodology

Previous studies concentrated on the determination of hydraulic properties of the aquifer system and assessing long-term source potential within localised areas of the WCB (Aquaterra 2007, 2009; FMG, 2012). The hydraulic testing undertaken by GSWA (1979) was limited by partially penetrating pumping wells, and there was only one aquifer test with an observation well undertaken at low flow rates.

The purpose of the field program was to assess the sustainability of the aquifer as per the existing conceptual model for the study area, in order to support a potentially major capital investment to develop a well field. A field investigation program was designed, to provide greater confidence in the regional distribution of hydraulic parameters.

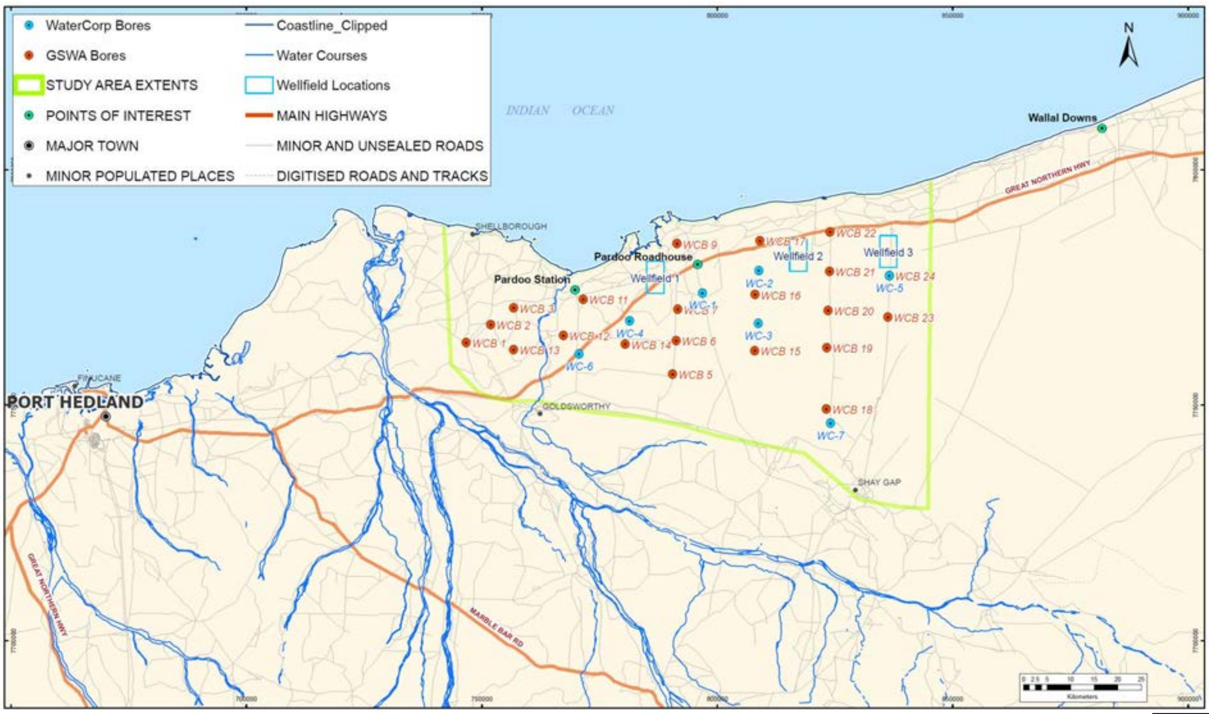

Figure 1: **Site location and well locations**

The target locations (Figure 1) were selected based on previous conceptual hydrogeological studies undertaken for the area and the following selection criteria:

- Potential to produce the quantity and quality of water required (Sites 1 to 5)
- No existing stratigraphic data (Sites 6A, 7A, 7B and 7C) (Refer to Figure 1 for locations).

Drilling, down-hole geophysical logging and well construction were undertaken at the specified target locations followed by subsequent aquifer testing and water sample collection.

Advisian (previously WorleyParsons) acquired the well completion reports and downhole geophysical logs from the GSWA study (1979). Drillhole samples were re-logged in order to correlate the lithological logs, downhole geophysics and drilling samples.

A desktop evaluation of available airborne geophysical data and interpretation was undertaken by GPX Surveys, which included modelling of the depth to Precambrian basement and structural interpretation. The hydrostratigraphy was described using; drillhole data, downhole geophysical logs, airborne EM and seismic depth models. The results were inputs to the subsequent groundwater modelling.

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Hydrogeological characterisation

Previous onsite work (GSWA, 1979; Aquaterra 2007, 2009; FMG, 2012) referred to the hydrostratigraphic succession at the project site as Broome Sandstone underlain by the confining unit Jarlemai Siltstone followed by the discontinuous Alexander Formation and underlying Wallal Sandstone. Jarlemai Siltstone is indicative of low energy; sediment deprived environments and has a high clay and silt content. It is identified in this investigation as dark grey-black puggy clay with a high plasticity.

An inspection of drilling samples obtained in the GSWA, 1979 study showed discrepancies in the interpreted depth and thickness of the Jarlemai Siltstone in some wells when compared with the information obtained during the 2012 investigation. At equivalent depths, Advisian (previously WorleyParsons) encountered lower Callawa Formation, which is a white to yellowish grey predominantly silt with occasional fine sand. GSWA (2003) describes the Callawa Formation as having two distinct units; the lower Callawa unit is believed to be deposited in a littoral near shore tidal to sub-tidal marine depositional environment. The upper Callawa unit is a coarser grained facies associated with fluvial deposition. Upon reviewing the drilling samples from the GSWA, 1979 study along with outcrop and samples collected during this investigation, it is interpreted that the Callawa Formation is ubiquitous across the study area and is likely to be laterally continuous with the Broome Sandstone towards the north. This is consistent with nearshore marine facies deposited during the same period. The Broome Sandstone thickens in the north where a discontinuous unconfined aquifer system exists.

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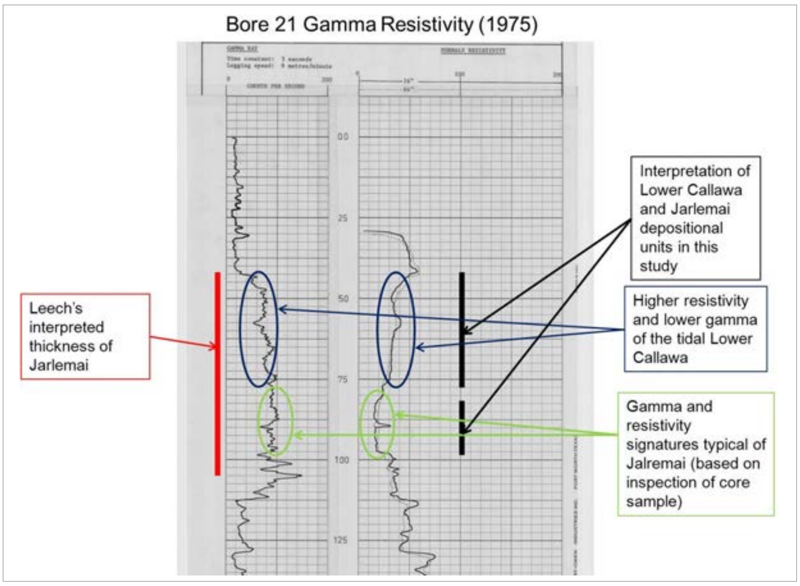
This observation was most critical in interpreting the extent of the area where Wallal aquifer potentially unconfined. It is generally accepted that the marine transgression resulting in the deposition of the Jarlemai Siltstone did not extend to the southern boundary of the study area. However, the lower unit of the Callawa Formation is present along the southern boundary of the study area (as identified at sites 6, 7A, 7B and 7C shown in Figure 1) where the coastal tidal margin of the marine transgression may have extended. It is evident from the recorded logs and inspection of the GSWA drilling samples that material described as Jarlemai Siltstone (dark grey puggy clay) may have been a part of the lower Callawa Formation (white to light yellow silty clay).

For example, for the well WCB 15, Jarlemai Siltstone was interpreted to occur between 23 to 63 mbgl. Equivalent samples collected from WCB 15 during this investigation indicate that the samples collected appear to be consistent with the lower unit of the Callawa Formation and none are consistent with the dark grey to black puggy clay with high plasticity (Jarlemai Siltstone).

Figure 2:
Downhole log for WCB 21, showing the typical signatures for the lower unit of the Callawa Formation and Jarlemai Siltstone.



This was also observed in WCB 21 where the Jarlemai Siltstone is recorded from 43 to 112 mbgl. The lithologs indicate that the lower unit of the Callawa Formation extends from 43 to 81mbgl with samples consistent with Jarlemai Siltstone from 81 to 112 mbgl.

This interpretation is supported by downhole gamma and resistivity for WCB 21 which shows a gamma trace more consistent with deeper water marine sediments and with a lower resistivity than the overlying more interbedded lower Callawa Formation depositional unit (Figure 2).

The lower unit of the Callawa Formation (aquitard) was observed in the southern locations (Sites WC6 and WC7 in Figure 1), which differs from the previously proposed conceptualisation, which assumes Broome Sandstone sediments to directly overly the Wallal aquifer in the south, potentially providing recharge to the system. This is also a critical observation in the conceptualisation of the hydrogeology of the WCB.

Based on the above observations and conclusions, a hydrostratigraphic classification system is proposed based on the inspection of field samples and mode of deposition.

This classification was adopted in this study and includes:

- Broome Sandstone
- Callawa Formation (upper and lower units)
- Jarlemai Siltstone
- Alexander Formation
- Wallal Sandstone (upper and lower units where identifiable).

Advisian (previously WorleyParsons) reinterpreted the GSWA logs, based on the analysis of the drilling samples and the downhole geophysics, to include the Callawa Formation units. This was done for consistency in building a conceptual hydrogeological model. The current study and the extent of the drilling program have not enabled the boundary of the lower unit of the Callawa Formation to be mapped to the south.

Analysis of the aquifer testing data shows the Wallal Sandstone aquifer behaves as a complex multi-layered aquifer system potentially influenced by local and regional palaeo-drainage systems. This is supported by the identification of channel structures in seismic surveying (FMG, 2012) and using the valley bottom floor analysis method developed by English et al.,(2012). The previous distribution of hydraulic parameters derived from GSWA (1979) showed a hydraulic conductivity gradient, east to west. Aquifer testing, analysis and interpretation of downhole geophysical logs show a higher degree of heterogeneity in hydraulic parameters with the highest conductivity values recorded in the east of the study area.

Palaeo-drainages from the south east, and more 'locally' from the south, draining off the Pilbara Craton may have resulted in significant reworking of Wallal Formation sediments. The resulting aquifer is highly heterogeneous, with grain size varying from coarse gravel and pebble beds to fine silt (in an overall fining up sequence) and hydraulic conductivity varying potentially up to three orders of magnitude.

Groundwater modelling

Groundwater modelling based on the conceptual model was undertaken using the finite-difference model MODFLOW NWT version 1.0.6 (Niswonger et al., 2011). The groundwater modelling assessed the impacts of different well field design scenarios on groundwater levels and evaluated the ability of the resource to yield the required demand. An estimation of the drawdown impacts was undertaken; the calculated heads and drawdowns were assessed against the draft allocation limits (DoW, 2012) and the impacts at existing wells were calculated.

No recharge was included in the model along the southern boundary as it was an outcome of this study. There may be localised recharge areas associated with reworking (palaeochannels) of the sediments and such occurrences could be identified with the assistance of targeted geophysical investigations.

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Conclusion

This study has drawn on previous studies undertaken within the project area and incorporated new data from this investigation to improve the conceptual hydrogeological understanding of the system, to assess its long-term water supply potential.

There are principally two main regional aquifer systems within the study area including the confined Wallal aquifer and the unconfined Broome/upper Callawa aquifer. The focus of this study was on the Wallal aquifer which is a complex multi-layered aquifer system that shows significant vertical and areal anisotropy and heterogeneity.

Higher hydraulic conductivity is associated with the palaeodrainage network sourced from the Pilbara block. The potential exists for cyclic fluctuation in pressure head in response to external forcing from ocean tides, earth tides and barometric fluctuation.

Recharge to the Wallal aquifer system remains unclear; however there is potentially significant recharge from regional sources in the south east where it is unconfined. Recharge along the southern boundary appears unlikely and was not included as input to the numerical hydraulic model.

Understanding potential vertical connectivity between the overlying aquifers is also important to characterise potential recharge.

Based on the findings, a non-potable water supply well field is a viable solution to meet the long-term demands for Port Hedland. The impacts to the environment and existing users are manageable. The principal objective of the investigation was to determine the viability of a non-potable supply; however the results of this investigation indicate the water quality is such that a potable supply is also possible.

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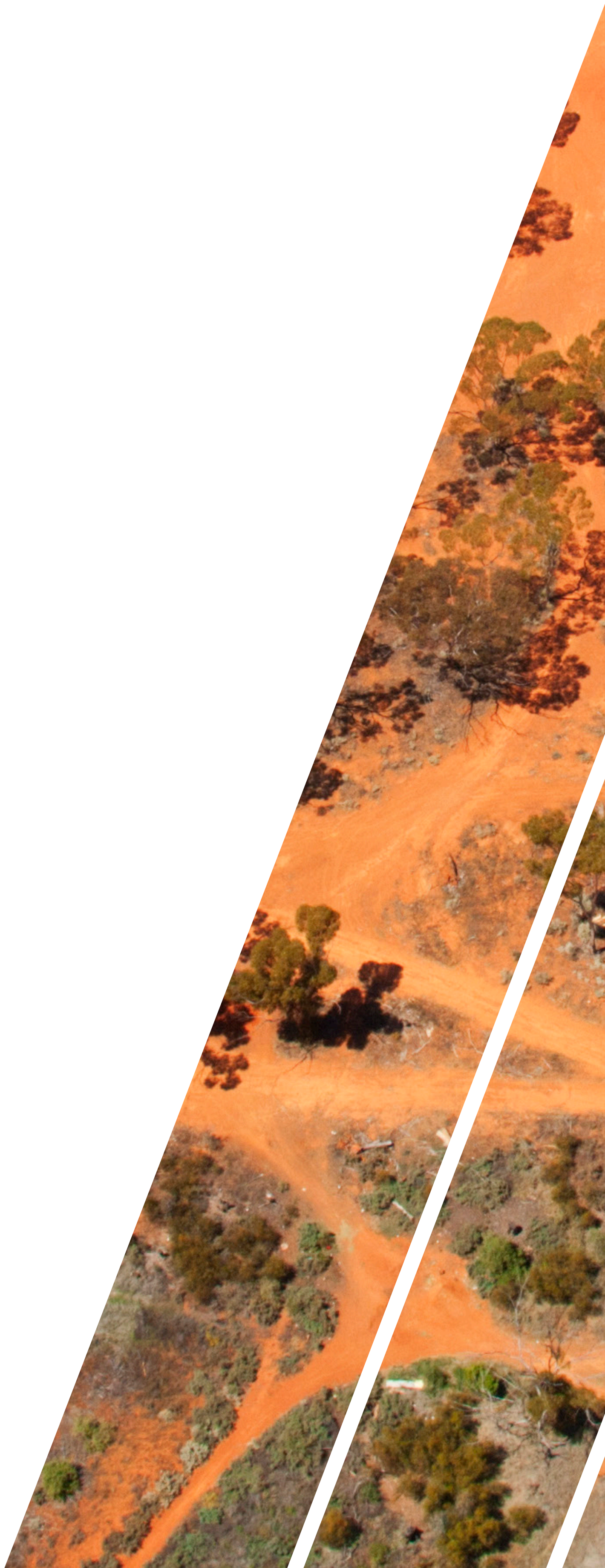

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