PEER REVIEW: MESA H: H3 HYDROGEOLOGICAL ASSESSMENT

INTRODUCTION

The Robe River Joint Venture (the Proponent) is undertaking studies to support additional mining operations that will sustain production from the Robe Valley. A number of channel iron deposits (CID) resources in the Robe Valley have been considered.

Mesa H is proposed as the next development to sustain the Mesa J hub production and is scheduled to commence Q1 2020 utilising existing Mesa J infrastructure including existing wet processing facilities.

Mining at Mesa H is scheduled to extend over a period of about 18 years. Water levels in much of the Mesa H mine area have been lowered significantly by dewatering activities at the adjacent Mesa J but further dewatering will be required as approximately 13% of the resource lies below the current water-table (BWT). Water supply augmentation for the expanded mining and processing requirements is also planned.

Pre-Feasibility Studies (PFS) have been completed and it is currently anticipated that the works will progress to a Feasibility Study (FS) in 2017/2018 with planned Implementation in 2019. The Proponent is currently planning to submit API/PER approval documents to in Q4 2017 seeking to obtain a Part IV approval by Q4 2018 / Q1 2019.

PROJECT OVERVIEW

Mesa H is located immediately west and adjacent to the existing Mesa J mine, downstream from the confluence of the Robe River and Jimmawurrada Creek.

The deposit is bounded in the north and northwest by the Robe River where riparian vegetation is extensive and a series of pools exist. One of these pools - Yeera Bluff - is a Rights Reserve site of high significance to the traditional owners.

Dewatering at Mesa H, combined with operations at Mesa J, has potential to lower water levels along the drainage courses.

A significant data base and dewatering/water supply experience has been gained over many years at the adjacent Mesa J site, where similar geological conditions exist, but there have been limited investigations at Mesa H prior to 2015.

A detailed PFS investigation was undertaken through 2015-2016 to address hydrogeological risks identified during an earlier Order of Magnitude (OoM) study – specifically, identifying dewatering requirements and assessing potential associated impacts to the Robe River. The 2016 programme comprised drilling, construction and testing of four (4) water bores with 32 associated monitoring bores the results from which were used (in conjunction with Mesa J data) to develop a conceptual hydrogeological model and subsequent groundwater numerical model.

PEER REVIEW

Provisions were made in August 2016 for an independent peer review of the hydrogeological assessments of the Robe Valley projects.

The key objectives of the review were identified as:

- Review and verify the quantity and quality of hydrogeological information considered as part of the assessment is sufficient to satisfy PFS level understanding and to support API/PER approval submissions
- Review and verify the current conceptual hydrogeological models including an assessment of technical robustness, rigour and level of confidence in the interpretations and analyses;
- Review and verify the numerical groundwater model inputs, design, calibrations and outputs and assess in terms of National Water Commission's Australian Groundwater Modelling Guidelines (2012);
- Provide recommendation to address gaps in the conceptualisation and numerical models.

Independent Groundwater Consultants Pty Ltd was commissioned to undertake the review which has been undertaken by Graham Smith, a professional hydrogeologist with 40 years of local and international experience specializing in arid zone hydrogeology with familiarity of the Pilbara and Robe River through site visits, a number of mine development projects and previous Rio Tinto commissions (e.g. member of Expert Panel; 2015 Pre-Feasibility Study for the Bungaroo mine; Peer Reviewer hydrogeological assessments for Warramboo, Mesa C and West Angelas C&D).

The review has involved review of project technical documentation, a site visit and several discussions with technical personnel as the studies have progressed.

This report presents comment on the H3 Assessment Report for Mesa H with primary attention given to data availability, hydrogeological conceptualisation, analysis and assessment methods, groundwater modelling, impact assessments, mitigation measures if/as appropriate, water management planning and proposed future work programmes. The review of the hydrogeological conceptualisations and groundwater models draws on the Australian Groundwater Modelling Guidelines (Barnett et al, 2012).

Key Documents

The primary reference document provided for review was:

- Mesa H: H3 Hydrogeological Level Assessment v4.0 (RTIO, October, 2017).

Supporting documentation included:

- Mesa H: 2016 Pre-Feasibility Study Hydrogeological Drilling Program Completion Report (RTIO, May 2016).
- Mesa H: Groundwater Modelling rev.E (RPS, October, 2017).

Report Overview

The primary report has been well-prepared and is well supported by figures, tables and Appendices providing detail on the bore completions, the numerical model and an assessment of surplus water discharge extent. It includes the following Sections:

Introduction – provides an overview of the deposit (local aquifers, nearby water courses and environmental setting) and the adjacent Mesa J mine where dewatering occurs to facilitate BWT mining and provide process supplies.

Climate and Rainfall – describes climatic conditions, provides annual rainfall data, outlines contributing catchments and provides Robe River annual streamflow data (from upstream Ngalooin Pool and downstream Yarraloola).

Hydrogeology – describes local geology, aquifer occurrence (CID, Wittenoom and Robe River alluvium) well illustrated with cross-sections, hydrographs illustrating water level drawdown resulting from Mesa J dewatering and responses to rainfall, predicted pre-mining and current water level contours, recharge/discharge processes, water balance, an extended section on Robe River hydraulics where an estimate of mean annual flow (50GL/year) is given and contributing factors associated with the occurrence and status of permanent and semi-permanent pools occurring along the drainage are discussed, with supporting hydrographs. This is followed by an overview of flooding within Jimmawurrada Creek and connectivity with upstream Bungaroo palaeochannels.

Four (4) hydrogeological conceptualisations are presented in recognition of stated uncertainties around the characteristics of the Brockman Iron Fm and continuity of the Wittenoom Fm. Constraints associated with the heterogeneity of the local Robe River alluvial aquifer and the paucity of drilling information north of Mesa H and in Jimmawurrada Creek are also identified.

Existing Groundwater Use – describes dewatering (sumps/trenches), abstraction from an external borefield (Southern Cutback Borefield – SCB – that provides process and potable water supplies) and re-cycling at Mesa J, the Pannawonica town supply borefield drawing ~0.7GL/yr since 1981 from the Robe River alluvium (~10km northwest of Mesa H) and the Bungaroo Coastal Water Supply borefield (permitted to supply up to 10GL/yr for the West Pilbara Water Scheme) located upstream ~20km southeast of Mesa H.

Groundwater Investigation – summarises the extensive hydrogeological investigations to support water supply and dewatering at Mesa J since 1987, establishment of 14 monitor bores at Mesa H in 2015 and the 2016 works comprising installation of four (4) test production bores and 18 monitor bores (with reference to bore completion reports given as Appendix A). A summary of pumping tests and results (3 bores in Mesa H and 18 in Mesa J) is provided. Reference is made to RTIO-PDE-0143871 (not sighted) in presentation of Robe Rive alluvial aquifer characteristics as determined from analysis of long-term abstraction from the Pannowonica town supply borefield.

Groundwater Chemistry – presents detail on extensive programme of groundwater (43 bores) and surface water (7 pools) sampling and analysis (since 1993 at Mesa J) with discussion of major ions, minor ions and isotopic composition to characterise the three main aquifers at the site and assess their potential contribution to the Robe River alluvial aquifer.

Groundwater Flow Model – summarises previous modelling works to predict inflows to Mesa J (initiated in 2002 and subsequently updated in 2003, 2004 and 2006), describes development of a new groundwater model in 2016 that combines both Mesa H and Mesa J (Modflow_Surfact v4.0 with Groundwater Vistas graphical user interface). Reference made to details provided in supporting Appendix B – Groundwater Numerical Model.

Difficulties associated with steady-state calibration and need for a dynamic calibration process are described with resultant good agreement between conceptual and model inflows and outflows.

Transient calibration, using annual time steps, compared predicted and observed groundwater levels through period 1990-2017 (using 37 bores with long-term records and 33 recently installed bores). Calibrated aquifer parameters are tabulated and a water balance presented. Zone budget analyses are described for the confluence of the Robe River and Jimmawurrada Creek and sites of inflow/outflow from the Robe River alluvium.

Model predictions are provided for dewatering of Mesa J and Mesa H and drawdown along the Robe River; these include augmentation of the SCB with an additional 3-5 water supply bores to meet the increased demand of the wet plant (8.7GL/yr) and continued discharge of surplus water along Jimmawurrada Creek the footprint of which as determined from a separate model. Reference made to details provided in supporting Appendix C –Surplus Water Discharge Extent Assessment.

Prediction uncertainty is discussed and eleven (11) additional model runs described for uncertainty analysis.

Assessment of Potential Impacts – using predicted 2037 water level drawdown resulting from dewatering and water supply discusses potential impacts (on water levels, the Robe river and Jimmawurrada Creek environments and the aquifer including predictions on post-mining water level recovery).

Site Water Balance – presents a detailed site water balance for each year through 2019-2037 identifying supply sources to meet demand for wet plant processing, infrastructure and dust-suppression.

Groundwater Monitoring – provides information on current (and planned) monitoring schedule from the approved site Groundwater Operating Strategy. Ongoing monitoring of flora, fauna and pools will continue in accordance with the Mesa J Environmental Management Plan. Risk to the environment with development of Mesa H is cited as high with acknowledgement that formal triggers (biological and water levels) will need definition prior to commencement of dewatering at Mesa H in 2024.

Management Approach/Conclusions – outlines defined Water Strategy, discharge system, maintenance and monitoring.

Key Findings

The key findings reported may be summarized as follows:

Aquifers

Groundwater occurs in three (3) main aquifers – the Robe River alluvials, the CID and the weathered basement (Marra Mamba Iron and Wittenoom Formations). Connectivity between the CID (to be dewatered during mining) and the underlying basement is constrained by the basal pisolites. Regional groundwater throughflow (CID and weathered basement) is estimated to be ~1.6GL/year.

Depth to water along the Robe River channel is shallow (2-5mbgl) and may fluctuate up to 3m annually in response to high rates of recharge and evapotranspiration. Natural groundwater throughflow is estimated to be ~0.8GL/year.

Conceptualisation

Groundwater flow in the CID and basement is from SE to NW following the trend of the CID palaeochannel deposits from upstream Bungaroo valley. The CID and Wittenoom aquifers are bounded by bedrock aquicludes (in the east by fresh Marra Mamba Iron Formation and by the Brockman Iron Formation in the west). Natural recharge is limited to direct inputs from rainfall but this has been locally augmented by leakage from Mesa J reservoirs.

Groundwater throughflow in the streambed alluvials of the Robe River and Jimmawurrada Creek naturally follows the drainage courses and are primarily recharged by infiltration of surface water flows that are generated by major rainfall events (supplemented locally by discharge of surplus water). The two principal drainages coalesce just upstream of Mesa H.

The pools that occur along the Robe River appear to be related to the alluvial aquifer and are groundwater dependent in drought periods.

A number of key uncertainties have been identified all of which may have significant impact on groundwater flow processes and responses to dewatering; these include aquifer characteristics of the Robe River and Jimmawurrada Creek alluvial systems. Four (4) different concepts are presented to accommodate primary uncertainties related to (a) whether the Brockman Iron Formation underlying Yeera Bluff is impermeable and (b) whether flow in the Wittenoom Formation discharges into the overlying Robe River alluvium or continues to the north.

Dewatering

Dewatering at Mesa H will commence 2024/2025 and, for all years, can be affected by in-pit sump pumping. Peak abstraction of 6.5ML/day will occur in 2033; total abstraction during LoM will be 11.3GL. Total abstraction 2019-2037 from the combined Mesa H and Mesa J operations, including water supply, will be 170GL with a peak of 9.5GL/year.

Water Disposal

Surplus water will be discharged to Jimmawurrada Creek at average rate of 2.1GL/year (peak 4.5GL). With potential discharge rates in range 5-30ML/day, the distance travelled by the surface water flow is predicted to be between 3.5km to 11.8km.

Water Demand and Supply

Water demand is dominated by the requirements of the Wet Plant which will require between 8.8 GL/year to 14.2 GL/year (average 11.9GL/year). Total water demand (including evaporative losses from on-site reservoirs) will range from 9.5GL/year to 15.6GL/year (average 13.3GL/year).

Dewatering product, seepage and decant recovery will make a significant contribution to supply but an external source will continue to be required; expansion of the SCB is planned to meet a maximum requirement of 8.5GL/year.

Impacts

Discharge of surplus water from Mesa J operations to Jimmawurrada Creek has likely contributed to maintaining water levels in the alluvial aquifer where no evidence of any impact on the aquatic environment has been found.

Combined dewatering operations at Mesa H and Mesa J will have minimal (<1m) impact on water levels along the Robe River north of the mines.

It is not expected that there will be significant impact to permanent pools in the Robe River (e.g. Yeera Bluff) but shallow semi-permanent and seasonal pools may dry out at a faster rate during prolonged periods when no surface water flows occur. Significant water level drawdowns will occur along a 9km reach of Jimmawurrada Creek as a result of the cumulative, combined impacts of Mesa J dewatering, abstraction from the SCB and the upstream Coastal Water Supply (CWS) borefield operation.

It is not anticipated that there will be any significant impact to riparian vegetation along the Robe River but there will likely be impact on phreatophytic vegetation along a 4-9km reach of Jimmawurrada Creek. Reductions in stygofauna habitats may also occur with lowering of water levels there but this is expected to be localised and minor.

Natural water levels will recover to pre-mining levels after 60 years.

Uncertainties

Inherent uncertainties exist with the parameters adopted to describe the hydrogeological system. Uncertainty analysis has been undertaken to evaluate conceptual model, climate change and numerical model uncertainties; results tend to confirm conceptualization and model behaviour.

Mitigation

The requirement for a mitigation strategy to supplement water to the permanent and semi-permanent pools in Robe River from 2030 (given uncertainties, values and ecosystem sensitivity) is identified. It is envisaged that monitoring of water levels in the Robe River pools and the area predicted to be impacted along Jimmawurrada Creek will be used to develop and trigger mitigation actions Options for mitigation have been identified (eg supplemental discharge, modification of abstraction regime, aquifer reinjection, etc.).

Planned Future Works

Planned works, cited in Scope of Work Mesa H FS Hydrogeology Drilling June 2017 v2.2, seek to address the hydrogeological risks identified in the PFS and include:

- Installation of up to six (6) test bores, eleven (11) monitor bores and two (2) VwP.
- Aquifer testing of all installed bores.
- Discharge trial (up to 30 days) in the Robe River (to support design of an impact mitigation strategy for local pools).
- Investigation of water supply sources for construction camp.

Review Comments

Field Investigations

The PFS investigations have been conducted to a high standard. Drilling, monitor and test production bore construction methods and aquifer testing conform to best-practice, are well documented and provide a sound data set for the Mesa H mine area.

Data Availability

Available rainfall and Robe River streamflow records have been included in the assessment; these demonstrate frequency of major rainfall and flood events. Groundwater levels and quality are well established with an extensive monitor bore network. Whilst there is limited discrete aquifer data, the adopted parameters conform to experience in similar environments and appear reasonable. No test data is provided to support the assumption that the basal pisolites constrain flow between the CID and underlying bedrock aquifers; based on the recorded lithology and thickness, however, this is considered a reasonable assumption. Data to characterize the alluvial aquifers associated with the Robe River near Mesa H and Jimmawurrada Creek near Mesa J are similarly absent. Aquifer parameters deduced from operation of the Pannawonica borefield appear reasonable and provide support for the parameters adopted for the Robe River alluvial aquifer. Uncertainties remain with regard to the alluvial system associated with, and surface water flows within, Jimmawurrada Creek. Notwithstanding the above, the cumulative data set is considered to provide an adequate technical foundation for the conceptualisations and detailed numerical modelling process.

Hydrogeological Conceptualisation

The geological model and characteristics of the primary hydro-stratigraphic units are well-established and provide a sound foundation for hydrogeological assessment. The conceptual model is based on the integration of all available information including background information from previous investigations, extensive experience in water management gained over many years at Mesa J where similar hydrogeological conditions exist, ongoing monitoring at Mesa J and information generated by specific investigations.

The concepts re: pools and alluvial aquifer processes is based on detailed assessment of available water level and water quality data and appear sound.

Uncertainties in conceptualisation have been clearly identified and adequately addressed in the modelling process.

Modelling

The objectives of the modelling are clearly stated and the model set-up honours the documented hydrogeological conceptualisation. Standard modelling packages and techniques have been deployed and what appear to be appropriate boundary conditions established.

Calibrated aquifer parameters are in general conformity with field-derived values; adopted low fresh bedrock values are considered appropriate. Inherent uncertainty exists with storage parameters.

Model predictions accommodate a number of assumptions related to many operational processes. These appear well-considered and further demonstrate a sound site water management plan. The assignment of surface water flows in Jimmawurrada Creek as a proportion of Robe River flows (based on contributing catchment areas) is supported.

Uncertainty analysis has usefully assessed conceptualisation and climate variables. Summary results indicate that drawdowns in the Robe River alluvials in excess of 1m are predicted to only occur in the sustained absence, or large-scale reduction, of flood flows. It is noted, however, that drawdowns of similar magnitude are predicted with modification of the general head inflow boundary associated with the Robe River which warrants further assessment.

The documentation for the modelling effort is of high standard and well-presented. The claimed model confidence level classification – Class 2 – is supported.

Dewatering

The predicted rates/volumes appear reasonable and gain support from the longer-term experience gained in the adjacent Mesa J pits where similar conditions prevail.

Impacts

Potential impacts have been identified and assessed. The dominance of surface water flows in the water balance (or indirect recharge derived therefrom) has, as would be expected, been clearly demonstrated.

The prediction that impacts along the Robe River north of Mesa H and Mesa J will be minor appear sound. Under average annual streamflow conditions and assumption of vertical flow constraints imposed by the basal pisolites underlying the CID aquifer, such impacts are less than natural seasonal variations and consequently considered unlikely to be of such a magnitude to pose any threat to local environmental values. Any water level drawdowns in the alluvials that do result from dewatering operations will, however, be naturally augmented in the absence of flood events. The contention that there will be natural mitigation of minor drawdown impacts along the Robe River by infiltration of surface water flows is supported by hydrographs from monitor bores showing water level responses associated with significant rainfall events (and assumed floods) along the Robe River (at Pannawonica) and Jimmawurrada Creek (near Mesa J) and appears reasonable.

The predicted significant drawdown impacts along a section of Jimmawurrada Creek are as would be anticipated given location near the SCB and predicted groundwater flow reversal resulting from continued operation of the upstream CWS borefield.

Uncertainties

A number of uncertainties have been identified that primarily relate to the aquifer characteristics of various formations, groundwater flow paths and hydraulic connectivity between formations. These should be adequately addressed in the planned, follow-on work programmes with further insight provided by continued monitoring.

Summary

The quantity and quality of hydrogeological information presented is considered sufficient to satisfy PFS-level understanding and to support API/PER approval submissions.

The current conceptual hydrogeological models have been developed on an extensive data set taking due account of local geology, hydrology, hydrogeology and historic site water management and are supported; uncertainties have been identified and will be addressed in follow-on programmes.

The numerical groundwater model honours the hydrogeological conceptualization and is considered fit for purpose meeting key objectives of quantifying required dewatering rates and potential impacts. Design conforms with standard practices and is based on a sound geological model; calibrated parameters are in accordance with field-derived or acceptable values. Information on calibration, predictions and uncertainty runs is well documented. In terms of the National Water Commission's Australian Groundwater Modelling Guidelines (2012), the reported Class 2 level of confidence is supported.

Model predictions indicate that:

- dewatering drawdown impacts along the Robe River will be minor and less than natural water fluctuations. Evidence exists to support contention of natural mitigation through infiltration of surface water flows.

- significant water level drawdowns will occur along a reach of the Jimmawurrada Creek as a result of abstraction from the nearby SCB and upstream CWS.

A requirement for mitigation measures has been identified; options exist and are to be further assessed.

Recommendations

Whilst the proposed work to advance hydrogeological understanding to Feasibility Level and continued monitoring should address the key uncertainties that have been identified, consideration should also be given to:

- Augmentation of the monitoring network with facilities to record flood events along both the Robe River and Jimmawurrada Creek and water levels/quality in any pools therein.

- Further examination of the available data sets with a view to confirming the areal extent, thickness and hydraulic properties of the basal pisolite layer.

- Obtaining discrete hydraulic properties of the key formations.

In addition, as a prelude to future modelling work, a re-assessment of boundary conditions would be prudent and further analysis of zonal water balances to confirm, and improve definition of, expected fluxes between the key formations.