09 May 2023

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Copy to	Pete Millar	Email	
From	Bas Wijers and Nick Deeks	Project No.	12596989
Project Name	Mulga Downs Bulk Earthworks Design		
Subject	Mulga Downs Water Studies: Groundwater & Surface Water Impact Assessment – Peer Review		

1. Introduction

Hancock Prospecting Pty Ltd (HPPL) is proposing to develop the Mulga Downs Iron Ore Mine (the Project) located approximately 210 km south of Port Hedland and 180 km northwest of Newman, in the Pilbara Region of Western Australia.

AQ2 has been engaged to undertake water (hydrological and hydrogeological) studies, including surface water and groundwater impact assessments, to support the environmental assessment of the project. As part of these studies AQ2 prepared a GROUNDWATER & SURFACE WATER IMPACT ASSESSMENT report (April 2023)

GHD have been appointed to undertake a Peer Review of the Surface Water Impact Assessment component of the report.

1.1 Purpose of this Memorandum

This Memorandum summarises the results of the Peer Review undertaken on the Surface Water Impact Assessment sections of the report.

1.2 Scope and limitations

The scope of work for this review extends only to commenting on the information provided within the GROUNDWATER & SURFACE WATER IMPACT ASSESSMENT report (AQ2, April 2023) The following report sections have been reviewed:

Table 1 Report review sections

Chapter	Title	Section
2	Field Investigations	2.1.1
4	Surface Water Data Assessment	All
5	Conceptual Hydrological Mode	5.1 to 5.5
7	Impact Assessment	All
8	Summary	8.1 to 8.3

This Peer Review: has been prepared by GHD for Roy Hill Iron RHIO and may only be used and relied on by RHIO for the purpose agreed between GHD and RH as set out in section 1 of this report.

GHD otherwise disclaims responsibility to any person other than HPPL arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on information provided to GHD and the professional experience of the authors. GHD disclaims liability arising from any of the assumptions being incorrect.

2. Peer Review Comments

Peer review comments on the various chapters in the report related to the surface water impact assessment are provided in the table below.

Chapter	Title	Content	Review Comment
2	**Field Investigations**		
2.1.1	Previous Investigations	Surface water monitoring locations established. 3 sited on claypan tributaries. 2 sited in claypans	SWML are representative of the site hydrology and target environmental value
		SWML equipped to record water depth and passive water quality sample after medium to large runoff event	Water depth measurements are appropriate for purpose of installation providing a continuous record. Water quality data is collected periodically. This could have been supplemented by installation of a water quality probe to provide a continuous record of a few key water quality indicators to match the water depth readings.
		Table 2.2 Claypan surface water monitoring stations	Showing a combined catchment area for the claypan, whereas there are two interconnected claypans. Be useful to split the catchment area for each pan. Also for use in the water balance model.
		SWML-05 was washed out during large rain event and reinstated later	Did recovered logger have observed data to inform study?
		Ongoing monitoring comprises the collection of surface water samples following rainfall events (where accessible) and periodic downloading of the loggers during groundwater monitoring rounds.	Methodology for ongoing monitoring is appropriate for baseline monitoring. Collection of a continuous water quality data in the claypans would provide a more realistic baseline water quality profile for the claypan year-round.
4	**Surface Water Data Assessment**		
4.1	Approach	2D flood model of valley including claypans and catchment runoff to characterize baseline hydrological conditions and potential impacts	GHD agrees with this approach

Chapter	Title	Content	Review Comment
		Water balance model if claypans to characterise baseline and impacts	GHD agrees with this approach
4.2	Catchment Definition	The baseline surface water catchments have been delineated using recent Lidar DEM, SRTM data, aerial imagery.	GHD agrees with this approach. Areas have been established for local catchments. The catchment area of the Fortesquw Valley at this location has not bee established
4.3	Flood Modelling – Baseline Conditions	A 2D flood model using the Hydrologic Engineering Center's (CEIWR-HEC) River Analysis System (HEC-RAS) was used.	The 2D model used is appropriate and consistent with industry standard practice.
		Baseline characterization through the simulation of 63%, 50%, 20%, 10%, 5% and 1% AEP runoff events	GHD agrees with this approach. This gives an adequate spread of frequent and extreme events.
		Mapping of maximum flood depths across the model domain for the design runoff events	This gives an adequate representation of hydrology and inundation areas during frequent and extreme events.
		Mapping of maximum flow velocity across the model domain for select runoff events	GHD agrees with this approach. This gives an adequate representation of hydrology and stream flow velocities which will indicate areas of stream erosion.
4.3.1	Stream Flow Data Analysis	The measured flow responses were compared with gauged rainfall data from the Mulga Downs Exploration Camp (MDEC) to identify rainfall events that produced a streamflow response.	GHD agrees with this approach
		A rainfall response event at SWML01a in January 2020, was selected as the only event suitable for use to calibrate the hydrological model.	Reasons give for the selection of the calibration event are sound, and GHD agrees with the approach. Perhaps 1 or two other events could have been chosen for model verification.
		A RORB rainfall routing model was developed for the catchment reporting to SWML01a using the January 2020 rainfall event.	GHD agrees with this approach. Calibration result in Figure 2.2 is acceptable fit.
		The model rainfall losses used to calibrate to this 5% AEP runoff event were translated to other AEP events based on extrapolating from the	The adopted loss parameters as shown in Table 4.2 are appropriate for the 10% and 5% AEP events / The adopted IL values for the 2%

Chapter	Title	Content	Review Comment
		variation in losses provided by Australian Rainfall and Runoff (AR&R; Institute of Engineers Australia, 1998)	and 1% AEP event are potentially a little high, when compares to the ARR value. What are the values selected for the other rainfall events modelled? (63% AEP etc) As the aim of this assessment is to determine the impact of the proposed project on hydrological characteristics by assessing the change in hydrological characteristics from baseline. By comparing the model results from Baseline and Developed cases, the choice of loss parameters is not as critical, provided they are the same in the baseline model and developed model.
4.3.2	Hydrological Modelling	RORB was used to generate inflow hydrographs for design runoff events	GHD agrees with this approach
4.3.3	2D Flood Modelling	The 2D flood model was developed using yhe 2022 LiDAR DEM that represents existing topographical conditions	This is an industry accepted method of hydraulic model development. Report would benefit from mentioning the vertical resolution of the model get an idea of accuracy.
		Model build data.	Model build data are appropriate for this application
		The modelling approach adopted is focused on providing baseline hydrological flood characteristics within local drainage lines immediately surrounding the proposed development during design storm events, but does not fully represent flooding within the full Fortescue Valley area (including the claypans) for the following reasons	GHD agree with the approach to focus on the characteristics as they relate to the local catchment and not include other sections of the Fortescue Valley. For the smaller and more local rainfall events this is fine. The report could include a description of Fortescue Valley flow events. However as these are not impacted by the proposed project this Valley component may be taken out altogether.
4.4	Claypan Water Balance	A water balance of the Gnalka Gnoona and Koodjeepindarranna claypans was completed to define the baseline hydrological regime of the claypans and to predict potential flood levels that may occur due to water storage within the claypans	GHD can only comment on the methodology. The water balance model has not been provided.

Chapter	Title	Content	Review Comment
		the model provides a reasonable overall approximation of the observed data. There is inherent uncertainty in the model due to the following main factors, which result in uncertainty in the model prediction	This model comprises several components for which reasonable assumptions have been made. On the basis of the calibration data provided, GHD agrees with the conclusion that the model is a fair reflection of the current baseline.
		Despite the uncertainty in the input parameters, the model provides a reasonable approximation of the hydrological behaviour of the claypans which can be used for this purpose.	With the uncertainty in the input parameters, this assessment would benefit from a sensitivity analysis.
4.4.7	Flood frequency analysis	A water balance model of the clay pans is presented, calibrated against 3.5-years of surface water monitoring data, and validated against satellite data. This model was simulated for 50-years to estimate flood levels over time. An annual series of flood levels was used in a flood frequency analysis to estimate the probability of different design floods in the clay plan.	The approach is reasonable; however, the validation is against a small selection of satellite observations when a larger continuous data set is available. An alternative approach likely to be more accurate is to use 35-years of satellite water observations instead of model data, as input into the flood frequency analysis. The low gradients surrounding the clay plans and availability of Lidar data allow for a reasonable conversion of flood extents to flood levels, for input into the FFA.
		Flood frequency Analysis and Claypan Peak Water Levels	The established peak water levels are unlikely to be impacted by the relatively small change in claypan inflows in a relatively wide valley.
4.5	Baseline Hydrology	The baseline maximum flood depths predicted by the flood model during the design rainfall events are presented in Appendix L, based on the existing terrain surface. Maximum velocity predictions for the 1% and 50% AEP events are also presented. Note that flood mapping is screened to only show areas where flow depths exceeding 0.1 m occur	The flood maps show simulated maximum water depths exceeding 0.1 m. With the likely sheet flow in the lower reaches where the streams fan out into multiple sub- streams and sheet flow, the use of a smaller cut-off depth (say 0.02m) would present a more complete understanding of the baseline hydrology.
4.6	Surface Water Quality Measurements	The collected water quality samples provide some baseline water quality data. However, given the naturally large	This assessment is based on the analyse 2-4 samples at 5 locations

Chapter	Title	Content	Review Comment
		variability in the runoff data, additional samples are required to be collected with time to provide a more robust baseline dataset which could be used to characterise the surface water quality for the Project. The water quality within the claypans will also vary with time as the runoff evapo-concentrates	over a period covering two hydrological years. This is a small data set and represents a snapshot baseline. Suggestion, that the use of water quality probes at these locations would have provided a better understanding of the seasonal variation in flows and associated water quality in the streams and claypans.
		The key observations made from the water quality data collected to date are as follows: • Aluminium, Zinc, Phosphorus, Sulfate concentrations measured are consistently above the trigger levels. • The samples taken in April 2019 consistently show elevated concentrations across a number of analytes and a number of monitoring locations. • The measured TDS concentrations of the samples taken from the claypans (SWML03 and SWML04) are variable (as expected) depending on the timing of the sample collection relative to the date of the inundation event.	These levels are consistently above the adopted ANZEC guideline. No trigger or threshold levels have been set as part of the water management plan. If these are consistently higher than the guideline than the baseline water quality should reflect this. A continuous measurement of key water quality indicators would have provided a better baseline in addition to the sampling analysis.
5	**Conceptual Hydrological Model**		
5.1 to 5.5			Review of the hydrogeology sections is not part of GHD scope. The conceptual hydrological model of the claypan is an integration of both surface water and groundwater components. The conceptual model as described in these section is a fair representation of the hydrological and hydrogeological environment of the Project area. The hydrological concepts described are supported by observed field data.

Chapter	Title	Content	Review Comment
			Ongoing monitoring of surface water flows , and water quality will further refine the conceptual model as representative of the project environment.
7	**Impact Assessment**		
7.1	Potential Impacts on the Hydrological Environment	The identification of potential impacts from the Project on the hydrological environment was completed by comparing the proposed infrastructure layout to the existing catchments and baseline flood modelling results	This an appropriate methodology to assess the change in hydrological characteristics of the project area/
		A detailed discussion of the proposed management measures is provided in the Surface Water Management Plan (AQ2, 2023b).	This information is contained in a separate report. GHD has received this report and read in reference. No Peer Review has been undertaken. To make this impact assessment report be more standalone, this section would benefit from a summary of the salient aspects of the Water Management report.
7.2	Surface Water Management Philosophy	The general management objectives for the Project relating to surface water are as follows: • Maintain the existing hydrological regime as much as is practicable. • Mitigate impacts on surface water quality from construction and operations by containing and treating impacted water on-site prior to release to the downstream environment. • Reduce the risk of surface water having a significant impact on mining operations.	These management objectives ensure a minimum impact on the surface water environment of the project area and a recognition of and maintenance of the environmental values and managing the operational risks to the project. The proposed surface water management measures to meet the stated objectives represent current best practice in the resources sector/
7.3	Modification of the Existing Hydrological Regime	The impacts of the Project on the surface water flow regime have been predicted by comparing baseline and LOM flood mapping, the results of which are presented in Appendix L	See review comment on Appendix L below
		Table 4.1	Probably needs to be renumbered to Table 7.1 Would benefit from the inclusion of totals to assess the total change in

Chapter	Title	Content	Review Comment
			catchment. Draining into the claypans. This turns out to be 11% of the local catchment excluding the inflows from the Fortesque Valley upstream/ This statistic already indicates that the impact of the project on the hydrology of the claypans is relatively small.
	Flood modelling Life of Mine	Results shown in Appendix K	A detailed model review is provided in Attachment 1
			Report would benefit from including all the modelled AEP results for velocity and afflux
		When creating the 2D LOM flood model, the grid sizing and model extent adopted for the Baseline Flood Model was used, with the footprints for the pits, waste rock dumps and topsoil stockpiles excluded from generating runoff to the surrounding environment within the model as surface water from these areas will be captured and retained within the WRD sumps	GHD agrees with this approach surrounding these areas with levee in the model is an appropriate method.
		The road and rail alignments have been accounted for within the model, with elevations for the rail being taken from designs and roads assumed to be raised 300 mm above the existing ground level. Gaps in the road and rail embankments have been inserted to simulate the installation of culverts at designated locations to allow surface water to drain downstream of the infrastructure	This methodology and approach are appropriate for this assessment.
	Claypan Water Balance Modelling – Life of Mine Scenario	Table 7.2	Would benefit from the inclusion of totals to assess the total change in catchment. Draining into the claypans. This turns out to be less than 5% of the local catchment This statistic already indicates that the impact of the project on the hydrology of the claypans is relatively small.

Chapter	Title	Content	Review Comment
74	Modification of the Physical Water Quality	It is assumed that the dirty runoff collected from the pits and waste rock dumps does not contain any chemical contamination that prevents the collected water from being discharged to the downstream environment. Work is being completed to assess the AMD risk of the pits and waste rock dumps, but the current management plan assumes that the site has a low AMD risk.	This section should deal with sediment management on the project, This statement refers to chemical water quality. The assumption is made in the absence of an AMD Assessment.
7.5	Modification of the Chemical Water Quality	Assessments of the AMD risk for the Project have not been considered when completing this impact assessment of the Project to the water quality in the downstream environment. A low AMD risk has been assumed, but AMD assessments are to be completed	This has been identified as a gap on the impact assessment, This should also be part of the conclusion and together with the recommendation to undertake an AMD Assessment and subsequent update of the Water Management Plan and Impact Assessment reports where necessary to be included in the Executive summary.
		The comparison indicates that the salinity will vary marginally between the Pre-Development and Post-Development model scenarios	This is a main finding, that belongs to b be mentioned in an executive summary
7.6	Summary	The surface water mitigation measures discussed above and outlined in more detail in the Surface Water Management Plan (AQ2, 2023b) and the Erosion and Sediment Control Plan (GHD, 2023) are anticipated to reduce all of the surface water risks identified for the Project to a Low risk rating, as shown in Appendix K.	
8	**Summary**		
	Conceptual Model	Surface water hydrological models are used to assess the impact of the project on the surface water environment	Methodology and model development and application are appropriate for this impact assessment
8.3	Surface Water Management	The Project development will reduce the catchment area which contributes surface water runoff to the Fortescue Valley	Suggest to add in the percentage of catchment reduction, , to place this statement into context/
		The residual risks of the Project to the hydrological environment were assessed taking into account the	This is the main conclusion of the surface water impact assessment.

Chapter	Title	Content	Review Comment
		proposed mitigation measures and the results of the flood modelling and claypan water balance modelling. The residual risks were generally considered to be low	The residual risk is low, and thus the impact of the project on the surface water environmental values is low. This is the main conclusion of the entire assessment! Suggest this summary at the end of the report is converted to an Executive Summary at the front of this report., with this statement as its opening line. In general, the report is very rich in analyses and perhaps a little light in interpretation and drawing conclusions.
		The claypan water balance quantified impacts to the claypans during a small, medium and a large inundation event. The impacts are considered negligible	As above. This comment would be better in an executive summary up front as a key finding.
Appendices			
APX A	Hydrogeological Modelling	Not part of Peer Review	Not part of Peer Review
APX B	Closure Assessment	Backfilled pits	Not part of Peer Review
APX C to M	Missing		Not part of Peer Review
APX K	Groundwater & surface water Risk Assessment	Surface water risk Assessment only	
APX L	Flood Mapping	Developed Scenario Flood Depth for 10%, 20%, 50%, 63%	Baseline flood depth maps are missing. Develop flood depth map are presented for selection of AEPs. Not all are presented. The 50% map has water depths missing
		Developed Scenario Flow Velocities for 50%, 63%,	Baseline Flow velocity maps for selected AEPs are not shown. Explanations required for choice of flow velocity legend selection. Suggest the use of less categories. One for non-erosive flows, one for

Chapter	Title	Content	Review Comment
			transition flows and a third for erosive flows Developed flow velocities for several AEPs not shown.
		Flood Depth Difference Maps for 1% and 50%	Explanations required for choice of flow change in flow depth legend selection.
			Suggest reordering the and regroup the presentation of flood maps. Baseline Flood depths and flow velocity maps (All AEPs) Developed Flood depths and flow velocity maps (All AEPs) Change maps for flood depths and flow velocity maps (All AEPs)

3. General Review Comments

In addition to the above the following general review comments are made:

– The Surface water Impact assessment has been undertaken at a level of detail appropriate to the proposed Project.

– The assessment of the available data and the results have been clearly presented and conclusions drawn are appropriate and supported by the data. The report would benefit from a data gap analysis and a recommendation for further ongoing monitoring.

– Conceptual surface water model and 2D numerical model are appropriate for application in this hydrological environment. As is the method for establishing catchment delineation.

Baseline Characterization

– Baseline Characterisation:

- 2D model methodology is correctly applied. Model parameters are appropriate for the project environment.
- Baseline characterisation using simulated water dep (areas of inundation) and streamflow velocities throughout the model domain forms the basis for surface water impact assessment of the project is appropriate methodology/

Claypan Water Balance Model

– Claypan water balance to define the hydrological baseline is an appropriate methodology provided all environmental components are accounted for and sufficient data is available to characterize them. In the absence of data, the methodology will suffer from assumptions. For example:

- seasonal variation of groundwater inflows
- assumed seepage rates.
- variations in evaporation rates due to changes in water salinity

– GHD did not review the claypan water balance model, only the description of the methodology in the report.
– The baseline results are an adequate match to the observed data.
– Suggest to include a sensitivity analyses to improve the confidence in the model results.

Impact Assessment

– Baseline flood depth maps show maximum flood depths greater the 0.1m. We recommend a reduction of the limit (to say 0.02m) to show the sheet flow areas in the lower reaches of the valley.
– Present change maps for all the AEPs simulated.
– Provide an explanation for the choice of stream flow velocity legend and clarify which flows are considered erosive.
– Typically, a hydrological and hydrogeological impact assessment describes the potential impact of the project during operation and after closure. This report would benefit from the inclusion of a separate section on post-closure impacts, applying the same methodology and including a pit lake water balance. This will enable the regulator to assess the temporary impact during project construction and operation and the permanent impact post-closure.

4. Conclusion

This peer review of the parts of the Groundwater & Surface Water Impact Assessment report (AQ2,April 2023) provides list of specific and general comments to be addressed by the authors. GHD conclude that, overall, the report achieves its objectives and purpose. We trust this peer review meets your requirements. Should you have any questions, please do not hesitate to contact the undersigned.

Regards

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Attachments

Attachment 1

Model review