Appendix K.

Fortescue - Solomon - Dec 2010 Peer Review (Hydroconcept)

Fortescue Metals Group Ltd

Peer review and model appraisal

Hydrogeological Assessment of the Solomon Project

14th December 2010

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Executive Summary

HydroConcept has reviewed all available documentation and completed a peer review of the hydrogeological investigation and assessment completed by Fortescue and their consultants.

The investigation and assessment approach has been appropriate for the sub-regional nature of the mining proposal. Despite problems with the hydraulic testing, there is an adequate appreciation of the hydrogeology along the CID aquifer. It is considered that the understanding of the groundwater conditions will continue to improve and develop with the progressive installation of dewatering and injection borefields.

Conceptual understanding of the CID aquifer is adequate and in line with similar aquifer systems throughout the Pilbara. There is a need for improved understanding of pool functioning and dependence on groundwater levels in the CID aquifer, particularly at Kangeenarina Pool near the proposed Trinity mine.

The numerical flow model is a simple representation of the hydrogeology. It is considered a preliminary model and has been reviewed as such. The primary purpose of the model was to assess dewatering impacts and volumes, in order to demonstrate that aquifer dewatering was achievable. Further model development will be required to incorporate complexities such as representing the pools and assessing mine closure strategies.

The review of the draft Water Management Plan highlighted three significant groundwater resources issues that will require commitment and further studies by Fortescue. These issues have been identified in the PER document but are not well discussed in the provided hydrogeological documentation relating to the Solomon Project.

It will be important for Fortescue to develop appropriate investigations and approaches to assess (1) Hydraulic functioning of the pools in Kangeenarina Creek (north of the proposed Trinity mine) and Zalamea Gorge (southeast of the Zion mine); (2) Mine closure impacts on groundwater resources such as pit lake creation, changing salinity and the need for long-term pool augmentation; and (3) installation of a low permeability barrier at the western end of Valley of Queens mine.

1. Introduction

This document provides peer review of the hydrogeological assessment and groundwater model for the Solomon Project. The proposed Solomon iron-ore mine is located in the Pilbara region of Western Australia. The project comprises two new iron mines (1) Firetail that will produce 30 Mt/year of Brockman fines being Bedded Iron Deposits (BID) and Detrital Iron Deposits (DID); and (2) Kings that will produce up to 50 Mt of Channel Iron Deposit (CID).

Groundwater investigations have been undertaken by MWH and groundwater modelling by NTEC, under supervision and direction of hydrogeologists within Fortescue Metals Group Ltd (Fortescue). The investigations and assessment modelling provide a sub-regional understanding of the hydrogeological conditions associated with the proposed Solomon mine site. These studies have contributed supporting information and provided the basis for groundwater resource decision-making within the Public Environmental Review (PER) document (FMGL, 2010).

The PER document was submitted to the Environmental Protection Agency in November 2010 (open for comment till 22nd December 2010). The PER submission noted that the groundwater investigations were still underway in November 2010. The field program and associated numerical modelling in support of the environmental approval process are now largely finalised. These studies detail the groundwater resource considerations of the proposed mine operation, and will inform the EPA and other Government agencies and assist in their decision making.

2. Scope

HydroConcept was approached to undertake a peer review of the groundwater investigations, conceptual understanding and numerical groundwater flow model relating to Solomon Project. The primary tasks involved being:

- Read and comment on the technical reports detailing a hydrogeological investigations / assessment of the Solomon Project compiled by MWH, and the numerical groundwater flow model by NTEC;
- Review the conceptual hydrogeology including an assessment of technical robustness, rigour and level of confidence in the interpretations and analyses that support the developed numerical groundwater model;
- Review the model as documented against the Murray-Darling Basin Commission (MDBC) Groundwater Modelling Guidelines;
- Review and comment on the Solomon Water Management Plan, and;
- Provide the peer review in the form of a written report.

3. Review Guidelines

The peer review is a technical critique of the hydrogeological studies undertaken by Fortescue and their consultants. The intent of the review was to evaluate all work components and establish whether the studies had adequately addressed the main groundwater resource issues related to the proposed mining operation at Solomon.

There are no recognised guidelines for reviewing conceptual hydrogeology and the suitability of the conceptual model for the purposes of numerical modelling. As such, the reviewer has used elements from within the Conceptualisation table – Model Review (MDBC, 2001) and provided additional comments where required.

The modelling has been broadly reviewed according to the two-page Model Appraisal Checklist in MDBC (2001). The checklist has a series of standard questions relating to the (1) Report; (2) Data Analysis; (3) Conceptualisation; (4) Model Design; (5) Calibration; (6) Verification; (7) Prediction; (8) Sensitivity Analysis; and (9) Uncertainty Analysis.

All efforts have been made to follow the MDBC guidelines and make the required assessment based on the report and information provided by Fortescue. The reviewer has had no involvement in development in the groundwater model, as recommended within the guidelines, and this model appraisal has been undertaken at the completion of the modelling process.

4. Reviewed Documentation

The reviewer was provided a large complement of technical reports to enable a thorough and comprehensive review of the conceptual hydrogeology and groundwater model. These supplementary reports ensured the reviewer had all the background information to facilitate a prompt and accurate review.

The primary documentation on which this review is based was:

1. MWH, 2010a, Solomon Project Hydrogeological Investigation – Draft; for Fortescue Metals Group, November 2010.
2. MWH, 2010b, Solomon Project Hydrogeological Investigation – Project Status Report; for Fortescue Metals Group, October 2010.
3. NTEC Environmental Technology, 2010, Solomon Project Groundwater Modelling; for Fortescue Metals Group, 3 December 2010
4. Fortescue, 2010, Solomon Project – Draft Water Management Plan, SO-RP-WM-0001_Rev1, December 2010.

Draft versions of documents #1 and #4 were evaluated by the reviewer in early December with a number of recommendations and improvements for Fortescue and MWH to incorporate prior to document submission. The other documents were all in final draft form, except for minor grammatical editing.

5. Peer Review

There are four components to the peer review of the hydrogeological assessment of the Solomon Project. It comprises (1) a review of the investigation and assessment methodology; (2) evaluation of the conceptual hydrogeology and its appropriateness for incorporating into the numerical groundwater model, (3) a summarised model appraisal against the MDBC modelling guidelines; and (4) observations on the draft water management plan.

5.1 Investigation and assessment methodology

Since 2008, Fortescue has undertaken several phases of hydrogeological investigation and assessment that have substantially improved knowledge and understanding of the hydrogeology both at a regional and local scale. The initial monitoring bores were constructed in abandoned diamond mineral exploration drillholes and have provided most of the baseline data for the site. This has since been followed by a staged groundwater investigation and assessment approach, which has resulted in continually improving groundwater understanding across the project area leading to the development of a numerical flow model.

5.1.1 Groundwater investigation

The large amount of geological and stratigraphy information collected during mineral exploration has proven an ideal starting point in understanding aquifer distribution. Document #2 undertook a review of the entire mineral exploration drillhole database and mapped the CID palaeochannel thalweg (deepest part). This data set reduced the required amount of groundwater investigation / aquifer delineation drilling at Solomon and enabled Fortescue to focus on understanding groundwater hydraulics and aquifer response to dewatering.

Document #1 presents a large amount of interpretation related to the aquifer testing completed at Solomon. Four test production bores were drilled, constructed and test pumped with two bores in the Valley of the Queens and two in the Valley of the Kings. Hydraulic testing was also carried out six previously-installed production bores, as well as a Rio Tinto Iron Ore rail construction water supply bore recently acquired by Fortescue Metals Group. In addition, extended hydraulic testing (7 and 10 days duration) was undertaken on two large-diameter test production bores (SPB1004 and Jorgermeister) in the Valley of the Kings.

Interpretation of the aquifer testing in Document #1 suggests that the CID aquifer was not adequately stressed. The main problem is related to inappropriate production bore construction with 200 mm bore diameter considered too small and unable to accommodate larger capacity pumps. Some of the bores were also only partially penetrating the CID aquifer resulting in significant well losses and inefficiencies.

The author considers that despite the problems with the aquifer testing that sufficient information on the hydraulic parameters have been collected. Regional trends are clearly evident with decreasing permeability towards the eastern extent of the Valley of the Kings, except for the western extent of the Valley of the Queens (in the vicinity of Weelumurra Creek) where the permeability decreases as observed in the tightening of the hydraulic gradient.

Hydraulic testing shows responses that are similar to fractured-rock, double porosity style aquifers. This is shown by an initial rapid drawdown related to storage flow in the fractures, followed by a period of stabilised drawdown, before the rate of drawdown increases again related to dewatering both the matrix and fractures.

The resultant parameters for transmissivity, hydraulic conductivity and storativity, summarised in Section 5.6, are considered representative of other CID aquifers in the Pilbara. These values are appropriate and of sufficient accuracy to enable meaningful groundwater resource estimation.

5.1.2 Groundwater assessment

Prior to undertaking numerical flow modelling, the stored groundwater resources in the CID aquifer were determined using Darcy's Law. This approach is a simple analytical technique which provides confidence and a useful reference for comparing with total dewatering volumes determined from the groundwater model. The key assumption is specific yield with the values of 20% is slightly high and the concept of 'commandable storage' could have been considered.

A range of monitoring data (bore hydrographs, hydrochemistry, etc) were reviewed and interpreted to develop a broader appreciation of the hydrogeology. The lack of discussion about the surface water hydrographs (Appendix K) relating to the pools was an omission, as there are a number of interesting observations and points of discussion. The author recommends that Fortescue should interpret the pool hydrographs as means of communicating the pool's hydraulic functioning and dependence on groundwater resources.

In order to evaluate dewatering volumes and potential for impact, NTEC were commissioned to construct a numerical groundwater flow. This is a standard approach for groundwater resource and impact assessment being in line with current hydrogeological practices throughout the groundwater industry. The appropriateness of the groundwater model will be discussed in Section 5.3 of this document.

5.1.3 Summary of methodology

Fortescue have followed a fairly typical / normal groundwater investigation and assessment methodology with a focus on determining hydraulic parameters due to the importance of dewatering for project success. The only shortcoming for consideration is the lack of discussion on the hydraulic functioning of the riverine pools.

5.2 Conceptualisation

The conceptual hydrogeology has been reviewed for its technical rigour, robustness and appropriateness for developing the numerical groundwater model. The format of this review is somewhat based on the Model Review questioning template in MDBC (2001) for lack of a formal standard.

5.2.1 Consistency with prior knowledge

Prior to the development of the Solomon project, there was a poor regional understanding of the hydrogeology and groundwater resources in this part of the Pilbara. There had been no regional groundwater investigations by State Government; hence no background knowledge of groundwater resources, which required Fortescue to develop its own understanding.

Since 2008, Fortescue has undertaken several phases of hydrogeological investigation and assessment that have substantially improved knowledge and understanding of the hydrogeology both at a regional and local scale. This process of continual improvement in understanding has resulted in any regional appreciation of groundwater resources being directly attributable to studies completed by Fortescue.

5.2.2 Consistency with required model complexity

In order to assess impacts to groundwater resources and the environment related to Solomon, a groundwater model has been developed to evaluate a number of different development and dewatering scenarios. There has been focused effort to understand groundwater resources in terms of hydraulics owing to consistent salinity distribution and importance of dewatering for project success. This approach has enabled Fortescue to develop a conceptual model that is consistent and meets the requirements of a groundwater flow model.

5.2.3 Clear definition of conceptual model

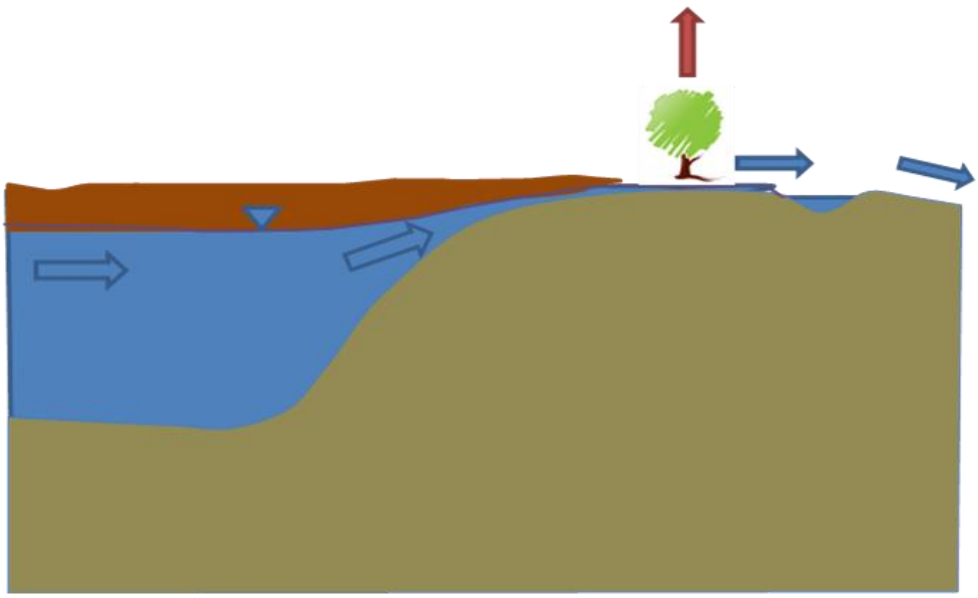
The conceptual model is broadly described in Chapter 6 of Document #1 with respect to aquifer horizons, groundwater flow, recharge and discharge. There would be certainly scope for a more detailed description of the conceptual hydrogeology; however, sufficient information is provided to understand groundwater flow and aquifer distribution within the CID. The cross section shown in the PER (Figure 5) provides an excellent illustration of watertable configuration and aquifer distribution throughout the Kings CID aquifer system.

The understanding of pool functioning and the dependency on groundwater level could have discussed in more detail. Though, it is evident that there is an appreciation of pool function in Chapter 6 with respect to the 'spilling over bedrock controlled outlets resulting in discharge to Kangeenarina Creek Pool and Zion Pool in Zalamea Gorge and how these two pools may only be present during periods of high groundwater levels within the Solomon aquifer system'.

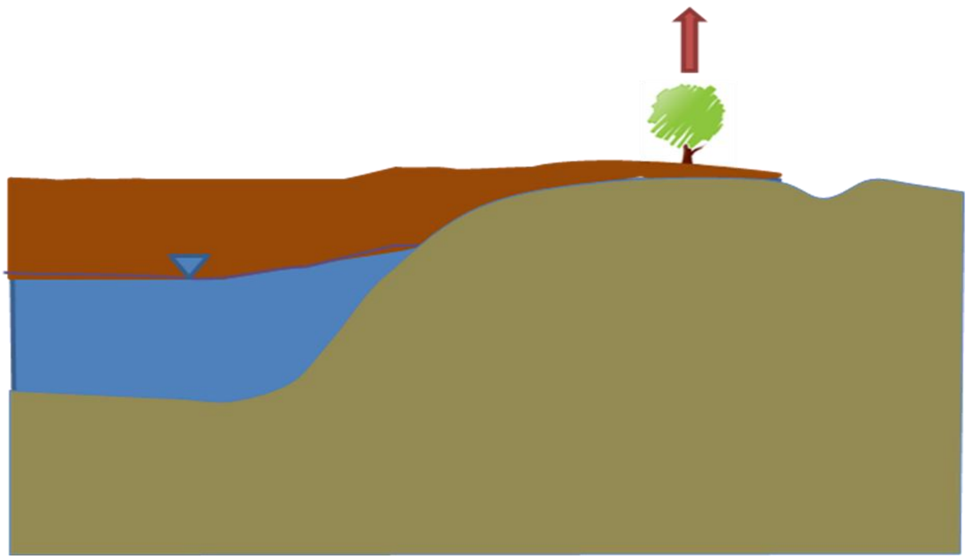
Schematic illustration highlighting the relationship between water levels in the CID and the pools would be extremely useful. The author has provided some illustrations as to assist with explaining the linkage and the importance of water level geometry and stage height for supporting the downgradient pools and associated vegetation.

There is also no discussion about post-mining impacts on water levels in the remaining / rehabilitated CID, the creation of pit lakes and long-term functioning of the pools. It is likely that dynamics within the pit lakes will have an impact on water level and potentially water quality in the pools. Indicative post-closure illustrations have been developed by the author.

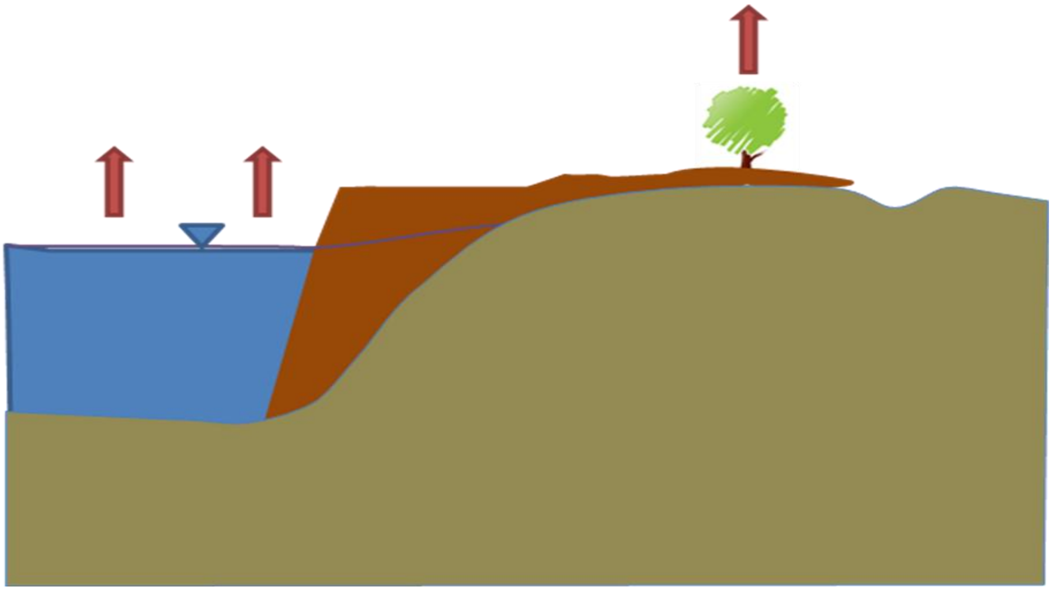
High groundwater level in CID aquifer (groundwater recharge)
– throughflow and discharge to pools



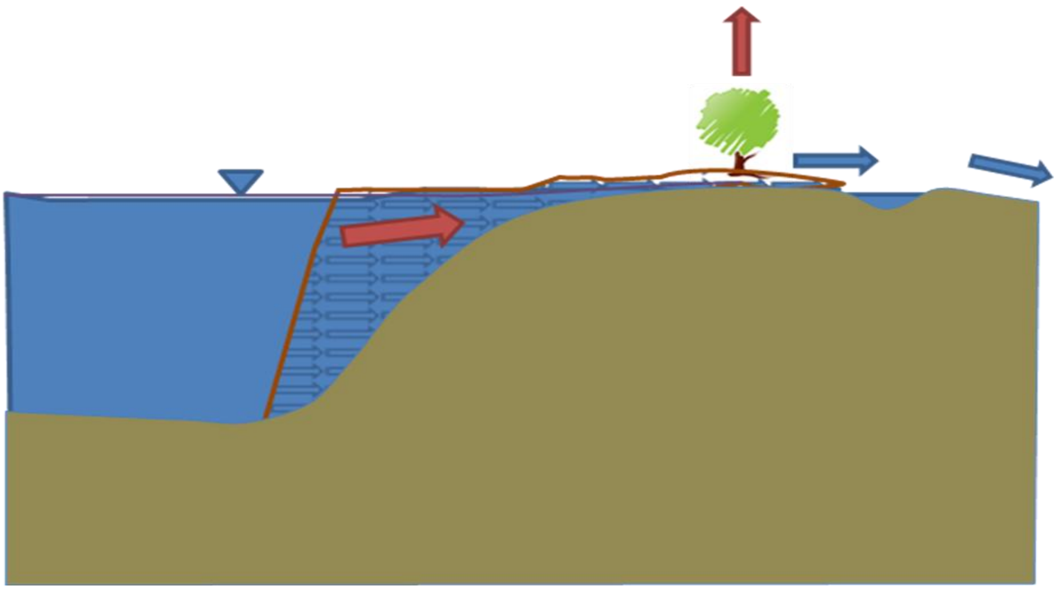
Lower groundwater level (low rainfall, dry season)
– no throughflow and no discharge to pools



Post mining in dry season – no throughflow and no discharge to pool.
Evaporation from pit lake – increasing salinity



Post mining in wet season –throughflow and discharge / overflow to pools.
Pit lake salinity being flushed from mine void?



5.2.4 Graphical representation

Figure 5 in the PER provides the most useful geological cross section illustrating aquifer relationships and distribution within the CID aquifer. In Document #1, Figures 2-7 and 2-8 provide regional positioning and scale of the CID aquifers, while Figure 2-6 presents a long-section through the Valley of the Kings highlighting the meandering nature of the CID palaeochannel. There are other figures that show groundwater flow (and its localised reversal in places) and groundwater salinity distribution. As mentioned previously, the inclusion of illustrations to explain pool functioning would be useful for explanation purposes.

5.2.5 Simple or complex conceptual model

The complexity of the conceptual model is adequate, but is considered simple due its sub-regional nature.

5.2.6 Appropriateness of the conceptual model

The conceptual model has been reviewed to assess its robustness and appropriateness for incorporating into the numerical groundwater model. The reviewer is satisfied with the interpretations used to develop the conceptual model.

Hydrostratigraphy

The understanding of the geological setting is considered the strongest element of the conceptual model. There is a good description of the stratigraphy for the major geological units, based on a large amount of mineral exploration and ongoing installation of production and monitoring bores.

The stratigraphy is relatively simple, which allows for an uncomplicated separation of the hydrostratigraphy. The author considers the hydrostratigraphical separation to be logical, appropriate and considered representative of geological conditions at the Solomon Project. It is likely that operational dewatering of the CID aquifer will reveal other complexities that may require consideration in the future.

Hydrogeological processes

There is limited description on the functioning of the groundwater environment and its representation within the numerical model. Chapter 5 and 6 in Document #1 as well as Chapter 2 of Document #3 discuss the approach for representing hydrogeological processes, such as recharge, discharge and groundwater flow.

Recharge – Recharge pathways are briefly described and could be more elaborated, but there is a broad appreciation of enhanced recharge on the palaeochannel flanks associated with detrital deposits and the significance of surface–groundwater interaction.

Hydraulic parameters – Document #1 presents aquifer testing methodology and results (including derived parameters) undertaken at the Solomon Project. Hydraulic parameters used in the numerical model have considered the aquifer testing and are appropriate for the hydrostratigraphic units.

Groundwater flow – Baseline groundwater contours have been compiled in Document #1 showing a throughflow groundwater system with localised reversal in gradient related to groundwater recharge mounds.

Functioning of the pools – There is insufficient discussion on pool functioning and their dependency on water levels in the CID aquifer. The water level hydrographs and salinity data in Appendix K show important recharge, flow and discharge responses that require further consideration and examination.

Hydrochemistry

There are few noticeable trends in hydrochemistry and groundwater salinity across the Solomon project area. All groundwater is fresh in all aquifers; however, there is limited appreciation of groundwater salinity in the surrounding bedrock aquifers. The piper diagram (Figure 5-9) in Document #1 shows groundwater evolution and modification resulting largely from evapotranspiration processes.

5.2.7 Summary of the conceptual model review

Fortescue have produced a reasonable and robust interpretation of the hydrogeology, and valid conceptual model. The conceptual model has a foundation with respect to the hydrostratigraphy within the CID aquifer. Despite problems during the aquifer testing, there is sufficient information to support development of a numerical groundwater flow model. There is additional work required to demonstrate pool functioning and post-mine closure impacts.

5.3 Model Appraisal

In terms of the modelling guidelines, the Solomon model is best categorised as an Impact Assessment Model of low complexity. The primary intent of the model is predict water level change and impact assessment with respect to the life-of-mine operation and associated dewatering activities. In the future, the model will form the basis of evaluating post-mine closure scenarios.

This model appraisal was undertaken at the completion of the modelling process, after calibration, prediction and final reporting. Table 1 follows the MDBC (2001) template for model appraisal.

5.3.1 The Report

To an external reader with no prior knowledge of the study, it is necessary to refer and read Document #1 for introduction before reading Document #3 that details the groundwater model. Fortescue has undertaken regional-scaled investigations, developed an appropriate conceptual model and numerical model. Document #3 provides a sufficient description of the modelling process and modelling results, which is considered consistent with the MDBC guidelines for model report structure (Table 6.1.1 in MDBC, 2001).

Table 1. Model appraisal (Part 1) – Solomon

Q.	QUESTION	Not Applicable or Unknown	Score 0	Score 1	Score 3	Score 5	Score	Max. Score (0,3,5)	COMMENT
1.0	***THE REPORT***								
1.1	Is there a clear statement of project objectives in the modelling report?		Missing	Deficient	Adequate	Very Good			Model objectives are clearly stated.
1.2	Is the level of model complexity clear or acknowledged?		Missing	No	Yes				It is assumed to be Impact assessment model of low complexity
1.3	Is a water or mass balance reported?		Missing	Deficient	Adequate	Very Good			A broad water balance has been presented as part of transient calibration
1.4	Has the modelling study satisfied project objectives?		Missing	Deficient	Adequate	Very Good			The model has largely satisfied project objectives
1.5	Are the model results of any practical use?			No	Maybe	Yes			Modelling results will support environmental approvals, water management planning and development of dewatering strategy
2.0	***DATA ANALYSIS***								
2.1	Has hydrogeology data been collected and analysed?		Missing	Deficient	Adequate	Very Good			There has been considerable effort in compilation and interpretation
2.2	Are groundwater contours or flow directions presented?		Missing	Deficient	Adequate	Very Good			Contours are presented for CID as whole but not for each aquifer - ? about connectivity
2.3	Have all potential recharge data been collected and analysed? (rainfall, streamflow, irrigation, floods, etc.)		Missing	Deficient	Adequate	Very Good			Recharge have been characterised
2.4	Have all potential discharge data been collected and analysed? (abstraction, evapotranspiration, drainage, springflow, etc.)		Missing	Deficient	Adequate	Very Good			There is insufficient documentation on pool functioning
2.5	Have the recharge and discharge datasets been analysed for their groundwater response?		Missing	Deficient	Adequate	Very Good			
2.6	Are groundwater hydrographs used for calibration?			No	Maybe	Yes			Hydrographs have been used to support calibration.
2.7	Have consistent data units and standard geometrical datums been used?			No	Yes				

Table 1. (cont.) Model appraisal (Part 1) – Solomon

Q.	QUESTION	Not Applicable or Unknown	Score 0	Score 1	Score 3	Score 5	Score	Max. Score (0,3,5)	COMMENT
3.0	***CONCEPTUALISATION***								
3.1	Is the conceptual model consistent with project objectives and the required model complexity?		Unknown	No	Maybe	Yes			The conceptual model is appropriate for the low model complexity.
3.2	Is there a clear description of the conceptual model?		Missing	Deficient	Adequate	Very Good			There is a good description of the conceptual model
3.3	Is there a graphical representation of the modeller's conceptualisation?		Missing	Deficient	Adequate	Very Good			Graphical illustrations are provided for contours but no schematic for conceptual model.
3.4	Is the conceptual model unnecessarily simple or unnecessarily complex?			Yes	No				Adequate balance in model complexity
4.0	***MODEL DESIGN***								
4.1	Is the spatial extent of the model appropriate?			No	Maybe	Yes			The model extent is adequate; reduces boundary effects within the model and represents flow in Weelumurra Creek
4.2	Are the applied boundary conditions plausible and unrestrictive?		Missing	Deficient	Adequate	Very Good			The applied boundaries are appropriate and related to hydrogeological reasoning.
4.3	Is the software appropriate for the objectives of the study?			No	Maybe	Yes			Modflow – Surfact Version 3.0 with Groundwater VISTAS v5

Table 1. (cont.) Model appraisal (Part 1) – Solomon

Q.	QUESTION	Not Applicable or Unknown	Score 0	Score 1	Score 3	Score 5	Score	Max. Score (0,3,5)	COMMENT
5.0	***CALIBRATION***								
5.1	Is there sufficient evidence provided for model calibration?		Missing	Deficient	Adequate	Very Good			Multiple lines of evidence; scattergram, comparison to hydrographs.
5.2	Is the model sufficiently calibrated against spatial		Missing	Deficient	Adequate	Very Good			Good calibration to groundwater contours and salinity distribution.
5.3	Is the model sufficiently calibrated against temporal observations?		Missing	Deficient	Adequate	Very Good			Transient calibration is good with reasonable correlation with hydrographs.
5.4	Are calibrated parameter distributions and ranges plausible?		Missing	No	Maybe	Yes			All parameters are considered appropriate and representative.
5.5	Does the calibration statistic satisfy agreed performance criteria?		Missing	Deficient	Adequate	Very Good			Scattergram suggests reasonable correlation, scaled RMS is 5% within acceptable range.
5.6	Are there good reasons for not meeting agreed performance criteria?		Missing	Deficient	Adequate	Very Good			No agreed criteria but model has met objectives
6.0	***VERIFICA TION***								
6.1	Is there sufficient evidence provided for model verification?		Missing	Deficient	Adequate	Very Good			Comparison of simulated and observed water level and salinity appear realistic.
6.2	Does the reserved dataset include stresses consistent with the prediction scenarios?	N/A	Unknown	No	Maybe	Yes			
6.3	Are there good reasons for an unsatisfactory verification?	N/A	Missing	Deficient	Adequate	Very Good			

Table 1. (cont.) Model appraisal (Part 1) – Solomon

7.0	***PREDICTION***								
7.1	Have multiple scenarios been run for climate variability?		Missing	Deficient	Adequate	Very Good			Synthetic rainfall pattern developed for transient but no apparent scenarios, but considered overly critical.
7.2	Have multiple scenarios been run for operational management alternatives?		Missing	Deficient	Adequate	Very Good			Simple dewatering scenarios have been completed for the mine plan; no post-mine closure scenarios
7.3	Is the time horizon for prediction comparable with the length of the calibration / verification period?		Missing	No	Maybe	Yes			Synthetic rainfall scenarios back to 1973. Limited calibration data with 3 years of monitoring
7.4	Are the model predictions plausible?			No	Maybe	Yes			The model provides reasonable estimations of dewatering considerations for mine water planning.
8.0	***SENSITIVITY ANALYSIS***								
8.1	Is the sensitivity analysis sufficiently intensive for key parameters?		Missing	Deficient	Adequate	Very Good			No apparent sensitivity analysis documented
8.2	Are sensitivity results used to qualify the reliability of model calibration?		Missing	Deficient	Adequate	Very Good			No apparent sensitivity analysis documented, but modeller has possibly considered
8.3	Are sensitivity results used to qualify the accuracy of model prediction?		Missing	Deficient	Adequate	Very Good			No apparent sensitivity analysis undertaken
9.0	***UNCERTAINTY ANALYSIS***								
9.1	If required by the project brief, is uncertainty quantified in anyway?		Missing	No	Maybe	Yes			No uncertainty analysis undertaken or documented.
	TOTAL SCORE								**PERFORMANCE:**

5.3.2 Data Analysis

Fortescue has collected and analysed hydrogeological data to develop the conceptual understanding and groundwater model. The hydrostratigraphy is well understood with separation into representative model layers; however, there is no discussion about hydraulic connectivity between layers.

The hydraulic parameters for these model layers have been derived from aquifer test data undertaken at Solomon. The stratigraphy has been simplified into a three layered model which is adequate given the data distribution and sub-regional understanding of the hydrogeology.

It is not documented whether there is a good understanding of groundwater flow within and between the different model layers. Though, the regional groundwater contours confirm a throughflow system with some localised reversal in groundwater flow.

5.3.3 Conceptualisation

The conceptual model is considered a reasonable interpretation of the hydrogeology. It has a strong foundation with respect to the hydrostratigraphy within the CID aquifer. In developing the model, NTEC have attempted to represent aquifer zonation within the lower CID aquifer (as observed in the pumping test data), attribute recharge relative to surface water tributaries, and evapotranspiration (via extinction depth) relative to depth to watertable; as well as discharge.

There is no clear and distinct illustration of the conceptual hydrogeology with respect to (1) hydrostratigraphy and groundwater flow; and (2) groundwater salinity distribution. This is an important requirement and is an omission from Document #3.

5.3.4 Model Design

The model has been built using MODFLOW-SURFACT version 3.0, in conjunction with Groundwater VISTAS v5. SURFACT allows for and can simulate variably saturated flow, which is useful for representing ephemeral surface water – groundwater interacting systems.

Model discretisation is 40 m x 40 m cells within the project area with all cells outside the palaeochannel being made inactive. The model represents the north-south Weelumurra Creek in a west-east direction which is separated by a row of inactive cells, which enables the potential effects / impacts to be modelled. In addition, the southern Kangeenarina Creek has been included (though there is still much to understand about this system) for injection scenario during project development and start up.

Model layering is consistent with the conceptual model. A simple three-layered model has been adopted reflecting the hydrostratigraphy within the numerical model. This approach is appropriate with hydraulic conductivity zonation applied in the Lower CID based on pumping test results.

There are no-flow model boundaries at the edge of the palaeochannel assuming that there is no groundwater entering from the surrounding bedrock aquifer, which is a conservative approach but appropriate given the lack of understanding about aquifer connectivity. Drainage cells have been included to represent discharge into Kangeenarina Creek with a base elevation at observed pool water level and a drain conductance that matches observed discharge.

The author would highlight that the no-flow boundary at the edge of the CID palaeochannel explains drawdown impacts being confined within the CID aquifer and not extending into the bedrock. This means that drawdown extents are slightly over-estimated and may be less during mine operation accounting for bedrock contribution.

5.3.5 Calibration

The numerical model has been calibrated for transient conditions across a period between 1954 and 2012 against monitoring bore records for the period 2008 to 2010. An appropriate calibration has been attained given the lack of long-term water level data, which significantly restricts the ability for calibration.

The modelled head and salinity distribution at calibration produced an RMS of 1.61 m and a scaled RMS of 5% given the range in observed water levels of 32.14m. These results are considered adequate for the low complexity of the numerical model.

A broad water balance was produced showing recharge contribution of 2.25 GL/yr across the model domain, which is considered realistic. Reduced evaporation and discharge is observed in model outputs reflecting the declining rainfall over the 2008 to 2010 period. There is also good match with water level decline within the model against observed water level change in the CID aquifer.

5.3.6 Prediction

Section 5 in Document #3 outlines the simulation approach used to predict mine dewatering requirements and impacts of an initial pit located in the Valley of the Kings. The exclusion of recharge from the simulation suggests that dewatering volumes are conservative, as an additional 2.25 GL/yr for spatial recharge is being not considered.

The proposed dewatering strategy has been represented as well as the inclusion of injection bores in the upstream end of the Kangeenarina Creek CID aquifer. The model scenario suggests that there is no re-circulation resulting from reinjection – this will be qualified when the injection bores are installed.

The results of the dewatering simulation are only briefly discussed in Document #3. The model has produced indicative dewatering rates and extent of drawdown impacts along the CID aquifer (Figure 11 in Document #3). It is important to remember that these drawdowns are constrained within the palaeochannel due to positioning of no flow boundaries (based on the assumption of no connection with bedrock aquifers).

The predictive results for dewatering and injection are illustrated in Figures 10 and 11 and show distinctive water level responses. A small mound is developed in the Kangeenarina

Creek CID aquifer while drawdown from the proposed Valley of the Kings mine appears to migrate and propagate along the CID aquifer.

Document #3 only discusses dewatering with respect to a 2 km long Valley of the Kings mine. There are no simulations for the life-of-mine assessing dewatering impacts related to the Trinity and Valley of the Queens mines. In addition, the no mine closure scenarios have been undertaken to represent post-mine conditions, in particular pit lake formation and long-term impact on the pools.

The main outcome of the model simulation was to demonstrate that the CID aquifer in the Valley of the Kings mine can be dewatered by a network of borefields. There will be a need for further model development to assess and consider the mine closure issues.

5.3.7 Sensitivity and uncertainty analysis

No sensitivity or uncertainty analysis has been undertaken and documented at this stage.

5.3.8 Summary of the numerical model appraisal

The numerical flow model is a simple representation of the hydrogeology. It is considered a preliminary model and has been reviewed as such. The primary purpose of the model was to assess dewatering impacts and volumes, in order to demonstrate that aquifer dewatering was achievable. Further model development will be undertaken to incorporate complexities such as representing the pools and assessing mine closure strategies.

The groundwater model of the Solomon Project can be used as an impact assessment tool to assess dewatering strategies. It has been developed competently and is meaningful representation of the hydrogeology, as Fortescue has utilised all available information and made appropriate estimations where required.

There are some shortcomings in the model simulation with respect to mine closure issues and considerations. It is presumed that Fortescue will commit to undertake additional studies and improved modelling to address the creation of pit lakes, as well as long-term management of water quality and water levels in the riverine pools.

5.4 Review of the Draft Water Management Plan

The author has provided feedback to Fortescue during the development of draft Water Management Plan. The plan provides an overall description of the hydrogeology and groundwater resource considerations related to the Solomon Project.

There are three major groundwater resources issues that will require commitment and further studies by Fortescue. These issues have been identified in the PER document but are not well discussed in the provided hydrogeological documentation relating to the Solomon Project. It will be important for Fortescue to develop appropriate investigations and approaches to assess:

(1) Hydraulic functioning of the pools in Kangeenarina Creek (north of the proposed Trinity mine) and Zalamea Gorge (southeast of the Zion mine). There is already baseline monitoring data that needs closer attention to develop an understanding of

groundwater dependency and the relationship between CID and pool water levels. This will be critical for developing augmentation strategies for maintaining the pools during mining and after mine closure.

(2) Mine closure impacts on groundwater resources – The resultant mine voids will only be partially backfilled resulting in the creation and formation of large pit lakes along the palaeochannel. These pit lakes will likely have a component of groundwater throughflow as well as inputs from surface drainages. There is some uncertainty about the long-term functioning of the pit lakes both in terms of throughflow and changes in groundwater salinity due to evaporative losses. The water level in pit lake will likely be lower than current CID aquifer, which may have implication on discharge to the pools and the need for long-term pool augmentation.

(3) Low permeability barrier at the western end of Valley of Queens mine – Mining in the western end of the Valley of the Queens has potential to induce groundwater flow from the north-south trending Weelumurra Creek CID aquifer into the mining operations. As such, it will be necessary to install a low permeability barrier to enable and facilitate safe working practices in the mine. A range of options (materials, etc) will need to be considered and studied by Fortescue.

6. Conclusions

HydroConcept has reviewed all available documentation (Documents #1 to #4) and completed a peer review of the hydrogeological investigation and assessment completed by Fortescue and their consultants.

The investigation and assessment approach has been appropriate for the sub-regional nature of the mining proposal. Despite problems with the hydraulic testing, there is an adequate appreciation of the hydrogeology along the CID aquifer. It is considered that the understanding of the groundwater conditions will continue to improve and develop with the progressive installation of dewatering and injection borefields.

Conceptual understanding of the CID aquifer is adequate and in line with similar aquifer systems throughout the Pilbara. There is a need for improved understanding of pool functioning and dependence on groundwater levels in the CID aquifer, particularly at Kangeenarina Pool near the proposed Trinity mine.

The numerical flow model is a simple representation of the hydrogeology. It is considered a preliminary model and has been reviewed as such. The primary purpose of the model was to assess dewatering impacts and volumes, in order to demonstrate that aquifer dewatering was achievable. Further model development will be required to incorporate complexities such as representing the pools and assessing mine closure strategies.

The review of the draft Water Management Plan highlighted three significant groundwater resources issues that will require commitment and further studies by Fortescue. These issues have been identified in the PER document but are not well discussed in the provided hydrogeological documentation relating to the Solomon Project.

It will be important for Fortescue to develop appropriate investigations and approaches to assess (1) Hydraulic functioning of the pools in Kangeenarina Creek (north of the proposed Trinity mine) and Zalamea Gorge (southeast of the Zion mine); (2) Mine closure impacts on groundwater resources such as pit lake creation, changing salinity and the need for long-term pool augmentation; and (3) installation of a low permeability barrier at the western end of Valley of Queens mine.

7. References

Fortescue, 2010, Solomon Project – Draft Water Management Plan, SO-RP-WM-0001_Rev1, December 2010.

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