Table 1
Snapper Mine and Ginkgo Mine Modification – Responses to Submissions

Submitter	Summary of Issue	Comment/Information Request	Response
NSW Office of Water	Water quality – complete analysis.	<u>Comment</u> *The Environmental Assessment (EA) has identified the proposal to extract groundwater from a deeper aquifer with the use of only 3 bores in comparison to the original 30 bores in a shallow aquifer. A component of the water extracted from the deeper aquifer is proposed to be recharged into the shallow aquifer. The EA has discussed the water quality of the two aquifers in terms of salinity (TDS) however no other water quality parameters are mentioned. It is therefore necessary for a comprehensive water quality assessment to be completed of both aquifers and is to include as a minimum, an analysis of major ions and pH. An assessment of the impact of mixing water from the two aquifers on the water quality is required.* <u>Information Request</u> *Complete analysis of the water quality of the deep and shallow aquifers targeted by this project and an impact assessment on water quality of the proposed recharge into the shallow aquifer.*	Attachment 1 provides a comparison of the available water quality data for bores within the shallow Pliocene Loxton-Parilla Sands aquifer and the deep Tertiary Lower Olney Formation/Warina Sand aquifer, between the Darling River and the Great Darling Anabranch. Available water quality data includes the following parameters (including major ions and pH): • pH; • electrical conductivity (EC); • total dissolved solids (TDS); • chloride; • sulphate; • bicarbonate; • potassium (K); • sodium (Na); • calcium (Ca); • magnesium (Mg); • iron (Fe): • manganese (Mn); and • phosphorus (P). • sodium (Na); The groundwater monitoring results indicate that the water within the shallow Pliocene Loxton-Parilla Sands aquifer has similar characteristics to water within the deep Tertiary Lower Olney Formation/Warina Sand aquifer (refer to Attachment 2, a Piper plot of the water quality, which shows that the waters from the different aquifers have similar characteristics and the same provenance [i.e. derived from the same geology]). This is consistent with the analysis of total dissolved solids (TDS) described in Section 8.5 of Appendix A of the Modification EA: *The water drawn from the Lower Olney/Renmark Aquifer has lower total dissolved solids (TDS), than water measured in the upper Loxton-Parilla Aquifer. Thus there will be a slight dilution of the dissolved salt in the upper aquifer around the Snapper Mine as a result of the proposed modification. This change will eventually migrate south over about 100 years. This effect is not expected to be measureable at any receiving environment.* Given the above, the modified Snapper Mine is not predicted to have any significant impact on groundwater quality of the Loxton-Parilla Sands aquifer.

Table 1 (Continued)
Snapper Mine and Ginkgo Mine Modification – Responses to Submissions

Submitter	Summary of Issue	Comment/Information Request	Response
NSW Office of Water	Water disposal dam – sediment build-up.	Comment *The EA describes the proposal to recharge water into the shallow aquifer via the water disposal dam in Year 6. It is not clear however how the issue of sediment build up in the base of the dam and potentially reduced infiltration is to be managed.* Information Request *Clarification on how the issue of silt build up in the base of the water disposal dam and potentially reduced infiltration rates is to be addressed.*	It is expected that there would be a high permeability within the backfill area given that it will not be comprised of consolidated *in situ* material. Should sediments build up in the base of the water disposal dam and reduce infiltration rates, one or more of the following mitigation measures would be implemented: • the water to be disposed of in the water disposal dam would be treated to remove/minimise sediment content prior to disposal (e.g. through the use of flocculant); • sediments would be removed from the base of the water disposal dam; and/or • the water would be directly re-injected into the shallow aquifer.
NSW Office of Water	Groundwater levels – presentation in Australian Height Datum (AHD).	Comment *The EA does not provide a clear indication in AHD of the existing groundwater level in the area of potential impact and the proximity of this groundwater level to current and proposed infrastructure (eg. Water disposal dam) and ground level. NOW also requires the groundwater contours presented to indicate groundwater response to be provided in AHD.* Information Request *The groundwater level to be presented in AHD in the area of potential impact and the proximity of this groundwater level to existing and proposed infrastructure and ground level. It is also requested for the groundwater contours utilised to represent the groundwater response to be provided in AHD.*	Attachment 3 provides the desired water disposal dam water levels for each year of the Snapper Mine in relative level (RL) metres (m) Australian Height Datum (AHD). The natural ground level at the site for each year of the Snapper Mine is also provided in Attachment 3 in RL m AHD. The modelling indicated a maximum mounding of the groundwater level beneath the water disposal dam to approximately RL 47 m AHD, (i.e. approximately 13 m above the existing watertable [approximately RL 34 m AHD]). Attachment 4 presents the groundwater contours presented as Appendix C of the Hydrogeological Assessment revised to show groundwater levels in RL m AHD.

Table 1 (Continued)
Snapper Mine and Ginkgo Mine Modification – Responses to Submissions

Submitter	Summary of Issue	Comment/Information Request	Response
NSW Office of Water	Water balance – presentation in simplified table.	<u>Comment</u> *The graphs used to represent the water balance for the two sites in the Hydrogeological Assessment are difficult to interpret and there is no clear representation of water inputs and outputs (surface water and groundwater) and storage level responses in the EA. It appears this is reliant on the groundwater modelling information.* <u>Information Request</u> *A representation of the water balance (inputs, outputs and storages) in a simplified form, preferably in a table to assist in understanding water use for the period of mine life.*	A simplified representation of the water balance (including inputs, outputs and storages) is provided as a table in Attachment 3.
NSW Office of Water	Groundwater modelling – guideline requirements.	<u>Comment</u> *NOW requires groundwater modelling to meet the standards of the guideline "Groundwater Flow Modelling Guidelines, Murray Darling Basin Commission (2000)". NOW requests confirmation the model used meets these guidelines.*	The groundwater model used in *Snapper & Ginkgo Mines – Hydrogeological Assessment* (GEO-ENG, 2010) meets the requirements of the *Groundwater Flow Modelling Guidelines, Murray Darling Basin Commission* (2000) (refer to the attached letter from GEO-ENG - Attachment 5).

Table 1 (Continued)
Snapper Mine and Ginkgo Mine Modification – Responses to Submissions

Submitter	Summary of Issue	Comment/Information Request	Response
Industry & Investment NSW	Final Mine Landform Height	Comment *I&I NSW note that the EA generally addresses the requirements of the Department with respect to mine closure and rehabilitation. However, the EA fails to adequately detail the increase in the final elevation (4 metres to 10 metres) of the landform profile along the alignment of the Snapper mine path.* Information Request *I&I NSW require the proponent to provide further information in relation to the increased height of the final landform profile of the Snapper mine path. Details that I&I NSW request are as follows:*	***Final Landform Height – Detailed Description*** The requirement to increase the final landform height is described in Section 2.3.1 of the EA. Figure 11 of the EA shows that, at any one time, the overburden removal area in front of the dredge pond is relatively wider than the area available for overburden replacement behind the dredge pond. Without a significant increase in the elevation of the replaced overburden in the final landform (i.e. from approximately 4 m to approximately 10 m) significantly more overburden would need to be stored off the mine path in a waste emplacement with either a larger area and/or a higher elevation. The volume of the final dredge pond would increase because the active mining area would increase. The requirement for this increase is described in Section 2.3.1 as follows: *This increase is due to:* • *…a flatter angle of deposition of sand residues and larger wet sand residue beach to allow for increased drying time (i.e. for safe placement of overburden as experienced at the Ginkgo Mine) and improved consolidation, which increases the active mining area (from approximately 1.6 to 3.4 km) and reduces the amount of area available behind the dredge pond for on-path overburden emplacement (i.e. overburden replacement cannot safely occur until adequate consolidation of the residues, consequently reducing the space available behind the dredge for on-path overburden replacement);…* As described in Section 5.3.2 of the EA: *The final dredge pond would be located at the southern end of the double-pass mine plan at the cessation of mining (Figure 8). The volume of the final dredge pond and surrounding pit would approximate the volume of overburden material that was removed during construction of the initial starter pit (i.e. approximately 34 Mm^3).* *As per the Snapper Mine EA, the final dredge pond would be partially backfilled with overburden material pushed down from the pit walls and from the final overburden emplacement area to a level some 2 m to 4 m above the local groundwater table.*

Table 1 (Continued)
Snapper Mine and Ginkgo Mine Modification – Responses to Submissions

Submitter	Summary of Issue	Comment/Information Request	Response
Industry & Investment NSW	Final Mine Landform Height (Continued)	*1. Details of alternatives to the increase in height;*	***Alternatives Considered*** The alternative to increasing the height of the final mine landform has been considered in Section 2.3.1 of the Modification EA. Also, as described on Figure 11 of the EA: *Without significant increase in the elevation of the replaced overburden, overburden must be stored off the mine path.* Increasing the size of the off-path overburden emplacement beyond that proposed would result in additional vegetation clearance or higher overburden emplacement.
		2. Details of consultation undertaken regarding the height of the final landform and visual impact;	***Consultation Regarding Potential Visual Impacts*** With regard to potential visual impacts associated with the modified components, as described in Section 4.3.2 of the Modification EA: *…the rolling topography, intervening vegetation and progressive revegetation of these landforms would limit potential impacts.* It is also noted that the proposed final landform height of approximately 10 m is less than the height of other approved landforms at the Snapper Mine (e.g. the initial overburden emplacement and initial sand residue dam have approved heights of up to 20 m). With regard to consultation, BEMAX understands that relevant government departments and landholders in the vicinity of the Snapper Mine were provided a copy of the Modification EA and invited to make a submission on the Modification EA. The Modification EA was also publicly exhibited. Submissions were received from I&I NSW, Department of Environment, Climate Change and Water and OoW.
		3. *Stabilisation and erosion control of the final rehabilitated landform.*	***Stabilisation and Erosion Control*** Slope stability and erosion control would be achieved by contouring the final slightly mounded landform to maintain appropriate slope length and runoff velocities. The batters of the final mine landform would be approximately 1:5. As described in Section 5.3.1 of the Modification EA, the low rainfall and lack of defined drainage channels in the ML area limits the potential for fluvial erosion and sedimentation. On-site water management measures including erosion and sediment control would continue to be implemented in accordance with the Snapper Mine Water Management Plan (BEMAX, 2008a). Erosion and sediment control measures for the modified Snapper Mine would also continue to be described in the Mining Operations Plan.

ATTACHMENT 1

GROUNDWATER QUALITY

Attachment 1
Groundwater Quality

Sample	pH	EC	TDS	Chloride	Sulphate	HCO_3	K	Na	Ca	Mg	Fe	Mn	P
	-	µS/cm[g]	mg/L	mg/L	mg/L		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Shallow Pliocene Loxton-Parilla Sands Aquifer Bores													
PW1, PW2, Snapper Bore 1[a]	6.9–7.5	–	–	–	–	–	–	–	–	–	–	–	–
M02, M19, M21, M26, M27, GW36669, GW36670[b]	–	31,500 – 66,100	21,105 – 44,287	–	–	200 – 590	43 – 58	12,000 – 16,000	730 – 900	1,000 – 1,400	–	–	–
M02, M19, M21, M26, M27[c]	–	–	–	16,000 – 24,000	5,500 – 8,200	180 – 500	32 – 59	12,200 – 17,300	700–890	1,000 – 1,430	0.043 – 4.7	0.015 – 1.2	0.05 – 3
Ginkgo Mine and Murray Basin Hydrogeological Map Series[d]	–	–	>35,000	–	–	–	–	–	–	–	–	–	–
Deep Tertiary Lower Olney Formation/Warina Sand Aquifer Bores													
SM2-2[e]	–	29,900	20,033	8,830	2,260	389	42.2	6,000	489	516	–	–	–
Snapper Bore[f]	7.1	–	–	10,400	2,510	355	46.9	12,100	464	559	9.2	0.513	0.21
Ginkgo Mine and Murray Basin Hydrogeological Map Series[d]	–	–	14,000 – 35,000	–	–	–	–	–	–	–	–	–	–

EC = electrical conductivity; K = potassium; Na = sodium; Ca = calcium; Mg = magnesium; Fe = iron; Pb = lead; Mn = manganese; P = phosphorus.

a Groundwater Quality Results for May 2010.

b Groundwater Quality Results as at November 2005 (including Table 4-4 of the Snapper Mine EA).

c Groundwater Quality Results for the period February 2008 to November 2009.

d Groundwater Quality Results for the Ginkgo Mine (Section 5.1, Appendix A of the Modification EA).

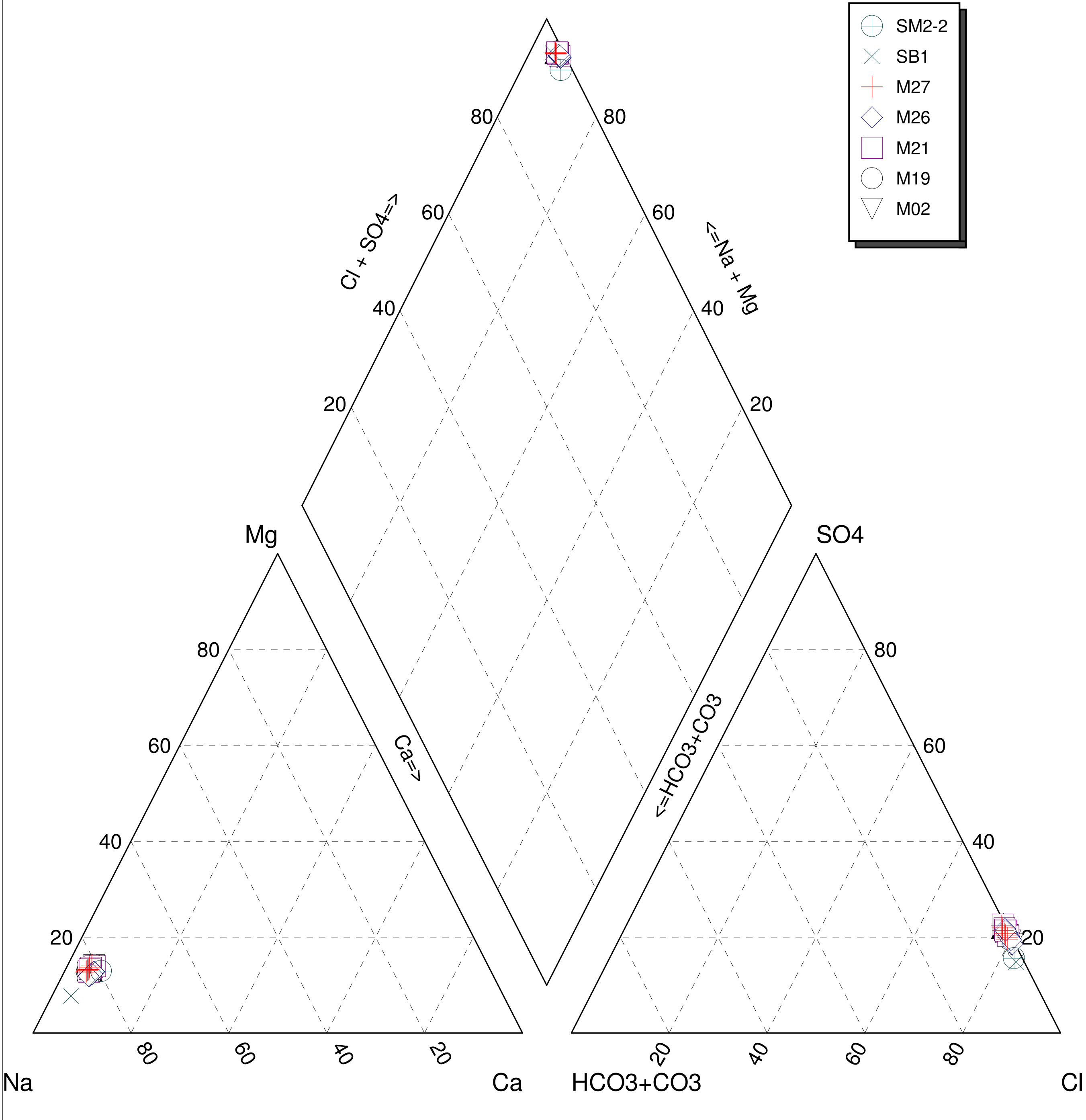
e Groundwater Quality Results for May 2008.

f Groundwater Quality Results for January 2009.

g microSiemens per cm (µS/cm).

ATTACHMENT 2

PIPER PLOT OF WATER QUALITY



DESCRIPTION: SM2-2, SB1: Warina Sand: M02, M19, M21, M26, M27: Loxton-Parilla Sands

GEO-ENG	PROJECT: Snapper Mine Water Provenance	PROJECT NO: 1004
	CLIENT: Bemax	DATE: 28/06/2010

ATTACHMENT 3

SNAPPER MINE SIMPLIFIED WATER BALANCE

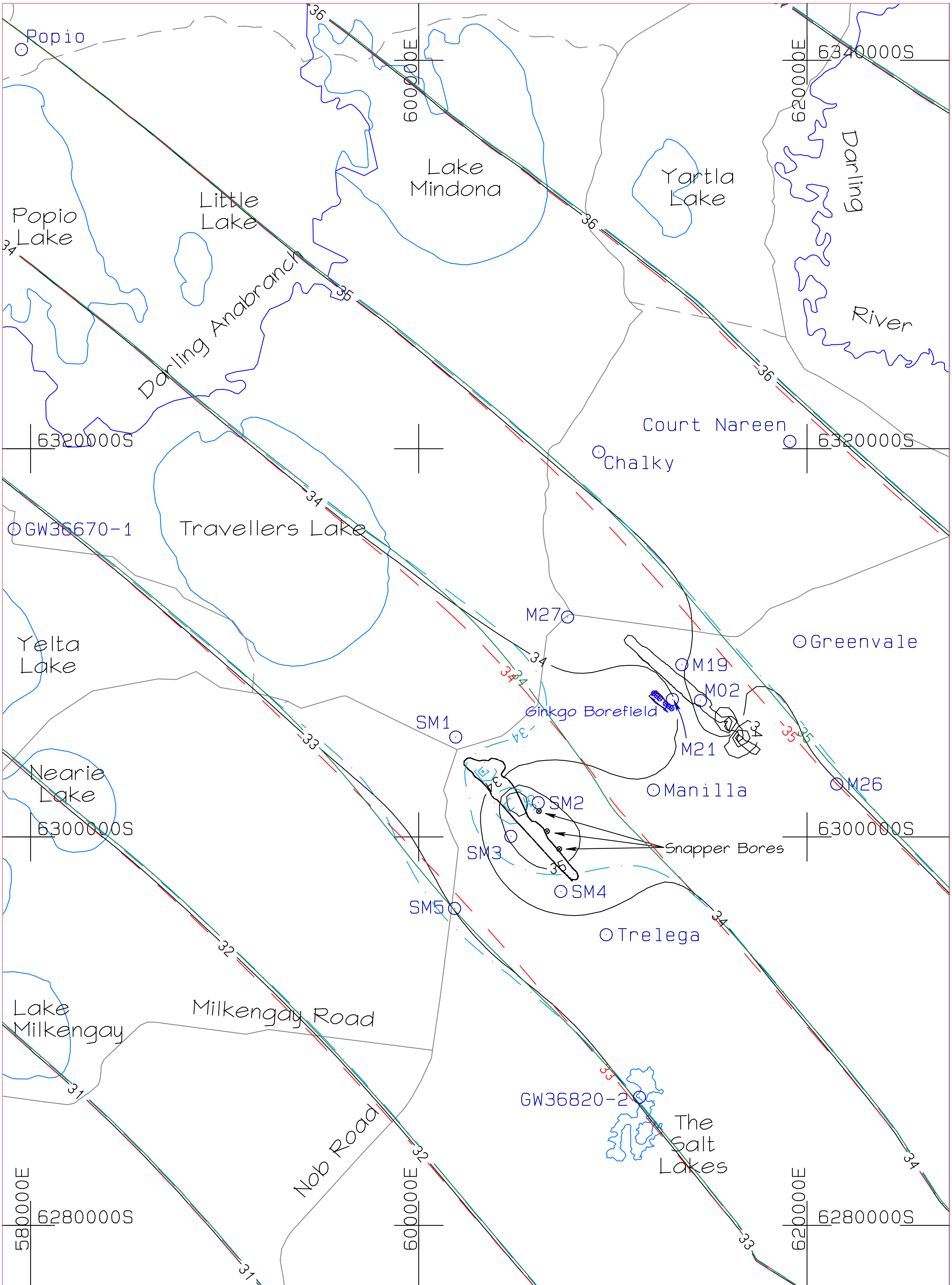
Attachment 3
Snapper Mine Simplified Water Balance

Year*	Mine Development Year*	Water Level (m) AHD			Water Flow (L/s)						
		Dredge Pond	Overburden Replacement	Topo	GDW gain	GDW loss	Dredge Pond Change	Offpath Overburden Replacement	Evaporation and other Losses	Water Supply Bores	Water Disposal Dam
2010	1	39	39	67	1	-37	-52	-76	-20	194	0
2011	2	40	40	77	3	-145	-26	-13	-21	200	0
2012	3	42	44	85	24	-159	27	-6	-22	139	0
2013	4	35	46	84	28	-140	-31	-6	-24	173	0
2014	5	38	43	80	48	-203	13	-4	-19	167	0
2015	6	34	40	80	60	-166	8	0	-13	111	0
2016	7	36	40	76	9	-90	8	0	-12	83	0
2017	8	34	38	66	18	-74	-41	0	-13	107	0
2018	9	34	34	74	24	-54	0	0	-13	51	0
2019	10	33	34	78	91	-41	31	0	-11	41	111
2020	11	28	33	75	105	-26	28	0	-9	41	139
2021	12	27	34	74	73	-4	-20	0	-10	49	88
2022	13	32	33	69	30	-15	-27	0	-12	56	32
2023	14	34	34	69	45	-49	10	0	-12	48	41
2024	15	37	37	75	34	-81	45	0	-10	44	32
2025	16	36	39	77	1	-10	56	0	-2	56	100

* 2010 and 2025 would be partial operational years only – i.e. the life of mine would be approximately 15 years.

ATTACHMENT 4

SNAPPER HYDROGEOLOGICAL ASSESSMENT GROUNDWATER CONTOURS PRESENTED IN AHD



19.5 x 26.41

North

Bemax Resources
Snapper & Ginkgo Mines

Upper Aquifer Contours (AHD)

Jul 2005 - Pre-Mining
Jun 2017 - 7 Yrs Snapper
Apr 2025 - End of Mining at Snapper
Apr 2035 - 10 Yr post Mining

Surveyed:	Plotted:	Design:	Contour int: 1m	DATUMS: Hor: GDA Ver: A.H.D.	A4 - 1 : 250000
BEMAX	Jun 29 2010	GEO-ENG	File No.: C:\FeFlow\S&G\import+export\Plots\159\S&GContoursAHDv2.pro		

ATTACHMENT 5

LETTER FROM GEO-ENG (DATED 30 JUNE 2010)

1004(C) MDR
30 June 2010

Mr Joe Bannister
Development Manager
BEMAX Resources Limited
PO Box 15164
City East QLD, 4002

RE: Snapper Mine and Ginkgo Mine Modification – Groundwater Model

Dear Joe,

I refer to the letter from the NSW Office of Water requesting confirmation that the FEFLOW groundwater model used in my *Snapper & Ginkgo Mines – Hydrogeological Assessment* (GEO-ENG, 2010) meets the *Groundwater Flow Modelling Guidelines, Murray Darling Basin Commission (2000)* (the Guidelines).

I am BEMAX Resource Limited's (BEMAX's) consultant hydrogeologist for the Snapper and Ginkgo Mines and I have over 20 years experience in hydrogeological modelling. My curriculum vitae is attached. I confirm that the 3-D Finite Element Groundwater Modelling software package (FEFLOW) groundwater model used in my *Snapper & Ginkgo Mines – Hydrogeological Assessment* (2010 Hydrogeological Assessment) (GEO-ENG, 2010) meets the Guidelines. In particular, the groundwater model meets the recommended guidelines ([a] to [i]) for achieving modelling study best practice presented in Section 1.7 of the Guidelines, and also passes all requirements listed in Table G1–Checklist for Model Compliance Assessment of Appendix G of the Guidelines.

FEFLOW was chosen for the refined model, due to its ability to represent large changes in model discretization over irregular areas, as it is based on the finite element method. FEFLOW is a highly recognized groundwater modelling software package, and is in use by a large number of hydrogeological consultants and government agencies in Australia and around the world. All parts of the FEFLOW simulation engine have passed an extensive benchmarking process where results are compared to those of other well-known simulation systems, to analytical solutions or to observations from lab experiments. The results of the current FEFLOW model compare favourably to the results of the previous finite difference MODFLOW model created by Golder Associates.

I provide below a description of how the model used meets the recommended guidelines ([a] to [i]) for achieving modelling study best practice presented in Section 1.7 of the Guidelines:

(a) Clearly state, at the outset, the model study objectives and the model complexity required.

The objectives of the hydrogeological assessment are stated in Section 2.0 of the *Snapper & Ginkgo Mines – Hydrogeological Assessment* (GEO-ENG, 2010), as follows:

> *The objectives of this hydrogeological assessment include the following:*

(d) If possible, a suitably experienced hydrogeologist/modeller should undertake a site visit at the conceptualisation stage.

I have undertaken site visits to both the Snapper Mine and Ginkgo Mine at various times.

(e) Address the non-uniqueness problem by using measured hydraulic properties, and calibrating to data sets collected from multiple distinct hydrologic conditions.

The 2010 model was able to utilise monitoring data from several years of mining, which allowed for improved calibration of groundwater parameters in the immediate area of Ginkgo Mine. As described in Section 6.5 of the 2010 Hydrogeological Assessment:

> *The model was initially calibrated under steady state conditions to match the groundwater levels determined by the Golder Associates model and against regional water bore levels. Subsequent transient calibration (which was not available to the previous model) was carried out against approximately 4.5 years of groundwater monitoring data around the Ginkgo Mine Site (Appendix A). The calibration indicates a good representation of the effect of dredge mining on the upper aquifer.*

(f) Perform an assessment of the model uncertainty by undertaking application verification, and sensitivity or uncertainty analysis of calibration and prediction simulations.

Refer to information provided above for Recommendation (e).

(g) Provide adequate documentation of the model development and predictions.

The development of the model is considered to be adequately documented in Sections 6.0 and 6.1 of the 2010 Hydrogeological Assessment.

The model predictions are presented in Section 8 of the 2010 Hydrogeological Assessment. The model predictions are also illustrated as contours in Appendix C of the 2010 Hydrogeological Assessment.

(h) Undertake peer review of the model at various stages throughout its development, and to a level of detail appropriate for the model study scope and objectives.

The model prepared for the 2010 Hydrogeological Assessment included review of the regional groundwater model developed by Golder Associates (2007 and 2008) for the approved Snapper Mine. Given that the current model is a refined model of the Golder Associates model, a specific peer review of the current model was not considered necessary.

(i) Maintain effective communication between all parties involved in the modelling study through regular progress reporting (technical issues and project management) and review.

Regular progress reporting was undertaken throughout the preparation of the model and the assessment report. GEO-ENG held regular meetings with BEMAX and conducted site visits to discuss technical issues and project management and the 2010 Hydrogeological Assessment was reviewed by BEMAX to confirm assumptions/parameters used in the modelling.

A model appraisal and model compliance assessment (Appendices E and G of the Guidelines), completed by GEO-ENG are attached for reference.

If you have any questions about this report or other issues, please contact me on 07 3711 5530 or 0423 200 355.

Sincerely yours,

Mark Robertson MASc, CPEng. RPEQ
GEO-ENG

MURRAY-DARLING BASIN COMMISSION GROUNDWATER FLOW MODELLING GUIDELINE								November 2000
MODEL APPRAISAL								Appendix E
Snapper & Ginkgo Mines – Hydrogeological Assessment (GEO-ENG, 2010)								
Q.	QUESTION	N/A or unknown	Score 0	Score 1	Score 3	Score 5	Max. Score	COMMENTS
1.0	***THE REPORT***							
1.1	Is there a clear statement of project objectives in the modelling report?		Missing	Deficient	Adequate	Very Good	5	Both the original and revised models have clearly stated objectives.
1.2	Is the level of model complexity clear or acknowledged?		Missing	No	Yes		3	
1.3	Is a water or mass balance reported?		Missing	Deficient	Adequate	Very Good	3	Both Models. Golder (2007,08) model includes regional balance. Revised model provides more accurate mine balance.
1.4	Has the modelling study satisfied project objectives?		Missing	Deficient	Adequate	Very Good	5	
1.5	Are the model results of any practical use?			No	Maybe	Yes	5	
2.0	***DATA ANALYSIS***							
2.1	Has hydrogeology data been collected and analysed?		Missing	Deficient	Adequate	Very Good	5	
2.2	Are groundwater contours or flow directions presented?		Missing	Deficient	Adequate	Very Good	3	
2.3	Have all potential recharge data been collected and analysed? (rainfall, streamflow, irrigation, floods, etc.)		Missing	Deficient	Adequate	Very Good	3	From Regional Model (Brodie 1998).
2.4	Have all potential discharge data been collected and analysed? (abstraction, evapotranspiration, drainage, springflow, etc.)		Missing	Deficient	Adequate	Very Good	3	Limited discharge locations within region of mine effect.
2.5	Have the recharge and discharge datasets been analysed for their groundwater response?		Missing	Deficient	Adequate	Very Good	3	From Regional Model (Brodie 1998).
2.6	Are groundwater hydrographs used for calibration?			No	Maybe	Yes	5	Both Models.
2.7	Have consistent data units and standard geometrical datums been used?			No	Yes		3	
3.0	***CONCEPTUALISATION***							
3.1	Is the conceptual model consistent with project objectives and the required model complexity?		Unknown	No	Maybe	Yes	5	
3.2	Is there a clear description of the conceptual model?		Missing	Deficient	Adequate	Very Good	5	Golder(2007)
3.3	Is there a graphical representation of the modeller's conceptualisation?		Missing	Deficient	Adequate	Very Good	5	Golder(2007)
3.4	Is the conceptual model unnecessarily simple or unnecessarily complex?			Yes	No		3	Golder(2007)
4.0	***MODEL DESIGN***							
4.1	Is the spatial extent of the model appropriate?			No	Maybe	Yes	5	
4.2	Are the applied boundary conditions plausible and unrestrictive?		Missing	Deficient	Adequate	Very Good	3	Sufficiently distance to have low sensitivity.
4.3	Is the software appropriate for the objectives of the study?			No	Maybe	Yes	5	FE Model allows increased sensitivity to mine effects.
5.0	***CALIBRATION***							
5.1	Is there sufficient evidence provided for model calibration?		Missing	Deficient	Adequate	Very Good	3	
5.2	Is the model sufficiently calibrated against spatial observations?		Missing	Deficient	Adequate	Very Good	3	
5.3	Is the model sufficiently calibrated against temporal observations?		Missing	Deficient	Adequate	Very Good	3	
5.4	Are calibrated parameter distributions and ranges plausible?		Missing	No	Maybe	Yes	5	
5.5	Does the calibration statistic satisfy agreed performance criteria?		Missing	Deficient	Adequate	Very Good	3	Visual match to hydrographs.
5.6	Are there good reasons for not meeting agreed performance criteria?	N/A	Missing	Deficient	Adequate	Very Good		
6.0	***VERIFICATION***							
6.1	Is there sufficient evidence provided for model verification?		Missing	Deficient	Adequate	Very Good	3	
6.2	Does the reserved dataset include stresses consistent with the prediction scenarios?	N/A	Unknown	No	Maybe	Yes	0	No reserved data set as limited calibration data.
6.3	Are there good reasons for an unsatisfactory verification?	N/A	Missing	Deficient	Adequate	Very Good		
7.0	***PREDICTION***							
7.1	Have multiple scenarios been run for climate variability?	N/A	Missing	Deficient	Adequate	Very Good		Due to limited recharge, climate variability will have negligible effect over life of project.
7.2	Have multiple scenarios been run for operational/management alternatives?		Missing	Deficient	Adequate	Very Good	5	Model has been used for varying alternatives.
7.3	Is the time horizon for prediction comparable with the length of the calibration / verification period?		Missing	No	Maybe	Yes	3	Limited calibration data.
7.4	Are the model predictions plausible?			No	Maybe	Yes	5	
8.0	***SENSITIVITY ANALYSIS***							
8.1	Is the sensitivity analysis sufficiently intensive for key parameters?		Missing	Deficient	Adequate	Very Good	3	Regional effects are insensitive to mine effects.
8.2	Are sensitivity results used to qualify the reliability of model calibration?	N/A	Missing	Deficient	Adequate	Very Good		
8.3	Are sensitivity results used to qualify the accuracy of model prediction?	N/A	Missing	Deficient	Adequate	Very Good		
9.0	***UNCERTAINTY ANALYSIS***							
9.1	If required by the project brief, is uncertainty quantified in any way?		Missing	No	Maybe	Yes	0	The regional effect of the mining is negligible and thus the uncertainty has not been quantified.
	TOTAL SCORE							PERFORMANCE: %

MURRAY-DARLING BASIN COMMISSION GROUNDWATER FLOW MODELLING GUIDELINE				November 2000
CHECKLIST FOR MODEL COMPLIANCE ASSESSMENT				Appendix G
Snapper & Ginkgo Mines – Hydrogeological Assessment (GEO-ENG, 2010)				
Q.	QUESTION	PASS	FAIL	IF 'PASS': COMMENT; IF 'FAIL': CORRECTIVE ACTION REQUIRED
1	Are the objectives of the modelling study stated clearly?	Pass		Item (a) in text.
2	Are the objectives satisfied?	Pass		The objectives of the modelling study were achieved.
3	Is the conceptual model consistent with project objectives and agreed model complexity?	Pass		Items (a) and (b) in text.
4	Is the conceptualisation based on the full data set and a competent analysis of available data, and presented clearly?	Pass		Item (c) in text.
5	Has the conceptualisation been developed, endorsed or reviewed by a competent hydrogeologist (and revised if necessary)?	Pass		Item (h) in text.
6	Does model design/implementation conform with best practice?	Pass		The modelling work carried out by both Golder and GEO-ENG is considered to be best practice.
7	Is model calibration satisfactory?	Pass		Item (e) in text.
8	Are calibrated aquifer property values plausible?	Pass		The parameters used are considered to be appropriate for the geological materials.
9	Does model prediction/application conform with best practice?	Pass		The modelling work carried out by both Golder and GEO-ENG is considered to be best practice.
10	Is there an excessive number of 'Missing' or 'Deficient' task performances marked on the Model Appraisal or Model Review Checklists?	Pass		There is limited scope for verification and uncertainty has not been quantified given the negligible regional effects on the groundwater table due to the mining.

Mark D Robertson MASc CPEng	
GEO-ENG	
9 Statesman Crescent	(07) 3711 5530
Sunnybank Hills, Queensland 4109	(04) 2320 0355
mark@GEO-ENG.com	
BIRTHDATE:	December 26, 1963
CITIZENSHIP:	Canadian, Australian

EDUCATION

B.A.Sc ***(1st Class Hons)*** Geological Engineering, University of British Columbia, Canada, 1986. **Thesis**: Principles and Parameters for the Design of a Portable Shear Wave Source for Geotechnical Investigations.

M.A.Sc ***(1st Class)*** Geological Engineering - Hydrogeology, University of British Columbia, Canada, 1990. **Thesis**: A Statistical Continuum Approach for Mass Transport in Fractured Media.

EXPERIENCE

- **Mineral Sands Mining**: Design and geotechnical assessment of dune reconstruction from tailings. Dredge and dry mining slope stability analysis and design. Tailings management and monitoring. Geotechnical assessment of erosion and varying failure mechanisms.
- **Environmental Management**: Catchment model studies to assess surface water/groundwater supply. Groundwater investigation to assess potential aquifer contamination of mine site. Drilling investigation, installation of monitoring bores, water sampling, groundwater modelling, assessment and recommendations for remediation and monitoring. Assessment of groundwater contamination monitoring at major landfill sites. Design, implementation, monitoring and assessment of a $1.2 M repair to a sensitive perched-water lake aquifer.
- **Contaminated Water**: Design and implementation of remediation systems for major diesel spill. Water sampling and monitoring for contamination and groundwater modelling of contaminant transport.
- **Contaminated Land**: Soil contamination sampling, design of contaminant testing programme, assessment of environmental impacts and cleanups.
- **Groundwater Modelling**: Large-scale 3-D finite-element groundwater models to assess moving mine impacts on sensitive groundwater dependent ecosystems and other groundwater users. Groundwater modelling for tailings and process water dams. Regional and local scale groundwater modelling for resource projects.
- **Salt-water Intrusion**: Review of salt water intrusion potential including groundwater modelling for a coastal sand island.
- **Groundwater Supply**: Design and installation of high-yield groundwater bores in varying environments.
- **Groundwater Monitoring**: Design and implementation of improved groundwater monitoring systems for mine programs. Hydrogeological studies for environmental management.
- **Mine Geotechnical Systems**: Development and implementation of mine site procedures for geotechnical and hydrogeological management. Training of operational and technical personnel in geotechnical and hydrogeological procedures.
- **Dam Design**: Tailings and Process Water Dam geotechnical designs for major mining projects.
- **Mine Dewatering**: Design and construction of bore and spear point dewatering system to manage groundwater levels around mine sites.
- **Rock Slope Design**: Field investigations, geological mapping, assessment of slope stability, design of rock slope protection. Development of toppling failure rock stability analysis model.
- **Foundations**: Geotechnical investigations, design of pavements and haul roads, design of pad, slabs, retaining walls, pier and pile foundations, preload design. Seismic Refraction and Pressuremeter Testing for dynamically loaded foundations.
- **On-site Effluent Disposal**: Assessment and design of on-site effluent disposal systems. Groundwater modelling to assess suitability of existing guidelines.
- **Probabilistic geotechnical analysis**: Development and implementation of Probabilistic slope stability and settlement analysis programs.

WORK HISTORY

2003-Present **Principal Geotechnical/Hydrogeological Engineer**: GEO-ENG.

2002-2003 **Production Services Superintendent**: Consolidated Rutile Ltd., NSI, Qld.

1997-2002 **Senior Hydrogeologist**: Consolidated Rutile Ltd., North Stradbroke Island, Qld

1994-1996 **Senior Geotechnical Engineer**: Golder Associates Pty. Ltd., Maroochydore, Qld.

1994 **Part-time Lecturer:** Griffith University, Qld. Environmental Geomechanics and Hydrogeology.

1992-1994 **Geotechnical Engineer**: Golder Associates Pty. Ltd., Brisbane, Qld.

1991-1992 **Geotechnical Engineer**: Coffey Partners International Pty. Ltd., Brisbane, Qld.

1986-1988 **Geotechnical Engineer**: British Columbia Hydro and Power Authority, BC, Canada.

AWARDS AND SCHOLARSHIPS

ARO E AHO Memorial Scholarship and Medal (top student in Geological Engineering UBC 1984, 1985 & 1986)
NSERC Postgraduate Scholarship, NSERC Undergraduate Research Award
Eleven other awards and scholarships.

AFFILIATIONS

Institute of Engineers Australia, Member, Civil College, CPEng, NPER-3 #618513.
Australian National Committee on Large Dams (ANCOLD) Member
Registered Profession Engineer of Queensland #6773.

PUBLICATIONS

Moon A, Robertson MD & Davies W, Quantifying rockfall risk using a probabilistic toppling failure model. Proceedings of the Seventh International Symposium on Landslides, Trondheim, 17-21 June 1996.

Tucker JS & Robertson MD, An overview of the methodologies used to determine soil permeability as part of the site assessment for disposal of effluent from domestic premises, Seminar on Domestic On-Site Wastewater Treatment and Disposal. Department of Primary Industries, Bundaberg. September 1995.

REFERENCES

Mr. Geraint Mathias	Technical Services Manager, Consolidated Rutile Limited, Brisbane (07) 3409-6992.
Mr. Joe Bannister	Development Manager, Bemax Resources, Brisbane (07) 3210-7900.
Mr. Peter Mollison	Principal Mining Engineer, Hale Mollison Consultants, 04234 462 309.