Expert Report to the Queensland Land Court by Dr Gavin M. Mudd

Proceeding MRA082-13 & EPA083-13

Report Finalised – 30 June 2013

Aerial photo of the Alpha test pit, 18 June 2013 (note wall failure in back corner; photo: N. Ham)

1. Expert Details and Qualifications

Name: **Dr Gavin Mark Mudd**

Position: **Senior Lecturer & Course Director – Environmental Engineering**
Dept. of Civil Eng. (Bld 60), Faculty of Eng., Monash University
Wellington Road, Clayton, VIC 3800
May 2003 to present (including time as Assistant Lecturer & Lecturer)

Qualifications: **Bach. of Environmental Engineering (Honours) *RMIT University* (1995)**
Doctor of Philosophy (Environmental Eng.) *Victoria University* (2001)

Experience: I have 18 years' experience in engineering practice and university teaching and research in assessing the environmental impacts of mining, including a particular focus on groundwater issues, mine waste management and the environmental assessment, monitoring and regulation of mining. I have also acted as an expert witness in four relevant court cases (three in Australia, one in Papua New Guinea). My 11 years of engineering teaching at Monash University has included 8 years of groundwater resources, 11 years of environmental impact assessment (amongst other subjects), supervising several post-graduate theses in groundwater and well over 100 final year engineering research projects on various topics, the majority of which include groundwater, environmental or sustainability aspects of mining.

A complete curriculum vitae is provided in Annexure A.

2. My Instructions

I was provided with specific instructions by Grant & Simpson Lawyers on 14 June 2013 and requested to provide an expert opinion in a report on the following three questions:

2.1 whether there is sufficient information to form an adequate scientific basis for approval of the mine having regard in particular to potential groundwater impacts and the reasons for your view;

2.2 whether, having reviewed all of the EIS documents, you agree with the conclusion of Coordinator General's assessment in relation to groundwater and the reasons for your view;

2.3 whether, having regard to all of the available material, there are issues that should be examined in more detail or additional lines of inquiry in relation to groundwater that should be explored before approval is granted and the reasons for your view.

I was provided with additional instructions by Grant & Simpson Lawyers on 28 June 2013 and requested to provide an expert opinion in my report on the following four questions (relating to the adequacy of the work performed to address the Terms of Reference for the Alpha EIA process):

2.4 baseline groundwater studies performed by the Applicant to establish the extent of impact of the proposed Alpha coal mine;

2.5 potential drawdown from the Applicant's proposed mining activities or the cumulative effect with other proposed projects;

2.6 any impact that the proposed Alpha coal mine's groundwater drawdown or potential contamination may have on the Great Artesian Basin.

2.7 are there any issues that should be examined in more detail or additional lines of inquiry that should be undertaken in relation to groundwater before an approval is granted?

My responses are detailed below.

I acknowledge that, during the preparation of this report, I was instructed on an expert's duty in accordance with rule 426 of the Uniform Civil Procedure Rules 1999 and I understand and have complied with that duty. I also verify that no instructions were given or accepted to adopt, or reject, any particular opinion in preparing my report – the views presented in my report herein are my own, except where acknowledged by citation using conventional practice for technical scientific writing.

3. Primary Documents I Have Relied Upon

Given the scope of the three questions, I have relied upon a range of primary documents and studies which are directly and/or indirectly related to this case:

3.1 *Alpha Coal Project Environmental Impact Statement – 6 Volumes*. Hancock Prospecting Pty Ltd (HP), Brisbane, QLD, November 2010 (HP, 2010).

- especially Volume 2, Section 12 – Groundwater; Appendix G – Groundwater.

3.2 *Alpha Coal Project Supplementary Environmental Impact Statement – 2 Volumes (Issue #4)*. Hancock Prospecting Pty Ltd (HP), Brisbane, QLD, September 2011 (HP, 2011).

- especially Appendix C – Out-of-Pit Tailings Storage Facility: Hydrogeological Assessment.

3.3 *Groundwater Modelling Report – Alpha Coal Project*. Prepared by URS Australia Pty Ltd (URS), Brisbane, QLD, 28 March 2012 (URS, 2012).

3.4 *Galilee Coal Project Environmental Impact Statement – 5 Volumes*. Waratah Coal Pty Ltd (WC), Brisbane, QLD, September 2011 (WC, 2011). (previously known as the China First project)

- especially Volume 2, Chapter 8 – Groundwater Resources; Volume 5, Appendix 14 – Groundwater Assessment.

3.5 *South Galilee Coal Project Environmental Impact Statement*. AMCI (Alpha) Pty Ltd and Alpha Coal Pty Ltd, Brisbane, QLD, October 2012 (AMCI, 2012).

A range of other reports and studies may be also used and appropriate citations are provided, using the conventional author-date system; all references are listed at the end of this report.

4. Question 2.1: Is scientific information sufficient for approval with regards to potential groundwater impacts?

4.1 In summary, NO.

4.2 To explain and clearly justify how I arrive at this view, I first provide a brief review of the regional and local geology as presented by Hancock during the EIS process, as geology underpins the groundwater system and how it behaves. I then highlight some inconsistencies with their conceptualisation of the geology and groundwater system, noting the contradictions between data and information in the various Alpha reports. I then present my interpretation of the local geology and groundwater flow system, as supported by the data and other documents and studies.

4.3 Hancock Coal's Presentation of Geology and Hydrogeology

4.3.1 A conceptual representation of the regional geology of the eastern Galilee Basin where the Alpha coal project is proposed is given in the Alpha EIS in Volume 2, Section 4, specifically Figure 4-2, and shown below as Figure 1 in this report. On this diagram, groundwater recharge is shown as occurring where the various sandstone units outcrop at or subcrop just below the land surface. Given the westerly dipping direction of the sandstones (eg. Hooray, Hutton, Clematis and Colinlea), the primary groundwater flow in these sandstones is therefore also shown as westerly. In the valley east of the Great Dividing Range where the Alpha coal project is situated, the local water table, comprised of shallow sands and lateritic soils, flows easterly away from the elevated range to the surface water feature of Lagoon Creek.

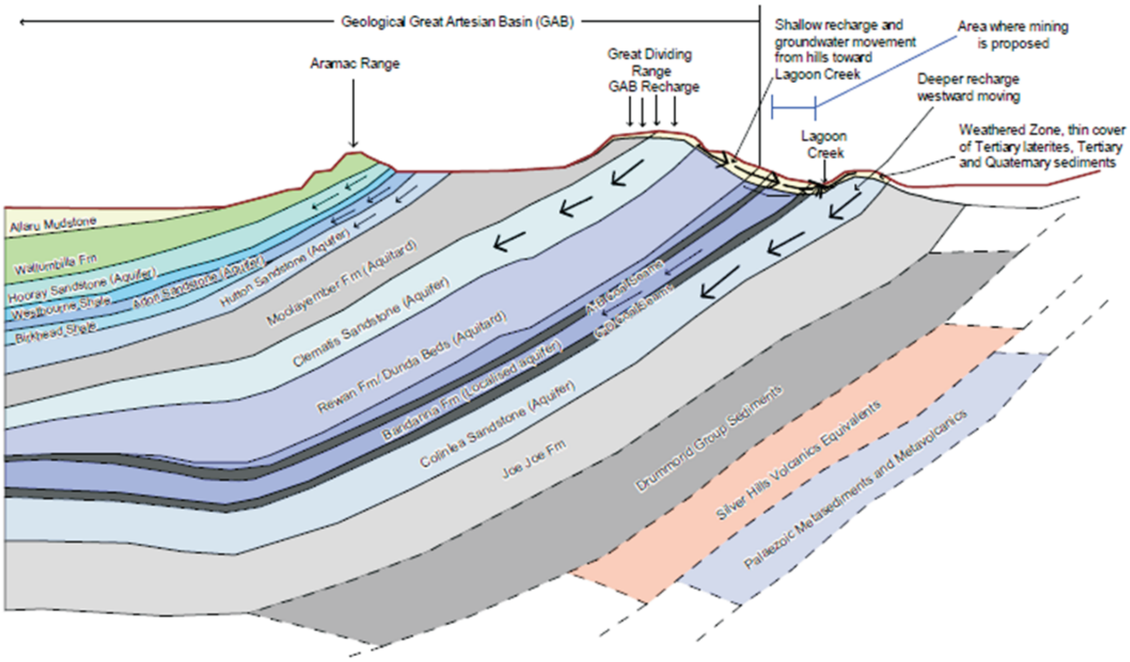

Figure 1: Regional conceptual geology and dominant groundwater flow pathways of the Alpha coal project region as given in the EIS (Volume 2, Section 4, Figure 4-2) (HP, 2010)

4.3.2 In the Alpha EIS (Section 12.8.10, Volume 2), the primary recharge and discharge mechanisms for groundwater are shown in Figure 12-9, and this figure is reproduced below as Figure 2.

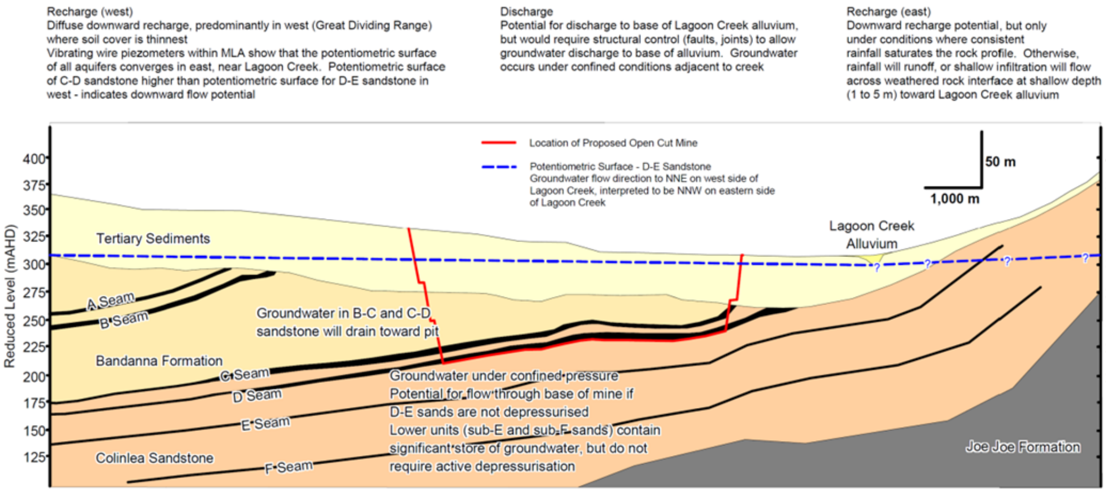

Figure 2: Conceptual representation of the local groundwater system for the Alpha coal project region as given in the EIS (Volume 2, Section 12, Figure 12-9; Note: image slightly edited for sharper presentation; no information changed) (HP, 2010)

4.3.3 In the Alpha EIS (Section 12.8.4, Volume 2), the primary recharge mechanisms for groundwater were considered to be direct recharge to sandstone outcrop areas and/or diffuse recharge from the Great Dividing Range. No specific field studies are provided to justify the magnitude or frequency of these recharge processes, only inferences or assumptions are given.

4.3.4 The groundwater pressures, or levels (or heads), for the deeper D-E sandstone unit of the Colinlea sandstone are shown in Figure 12.7 of the Alpha EIS, and given below in Figure 3. This shows groundwater flow moving to the north-northeast – in contrast to the westerly groundwater flow shown earlier in the EIS (see above). Such a situation is contradictory and both scenarios cannot be true at the same time.

4.3.5 The Alpha coal project Supplementary EIS (released September 2011) included some minor updates to the information available for groundwater, mainly monitoring data from the Alpha trial pit, but there was no substantive change to the conceptual view of the groundwater system.

4.3.6 After the Supplementary EIS, a major update of the groundwater modelling to assess potential groundwater impacts from the Alpha coal project was prepared by URS Australia for Hancock Coal in March 2012, including Hancock Coal's adjacent Kevin's Corner coal project to the north of Alpha (URS, 2012). Like the Supplementary EIS, there was no effective change in the conceptual representation of the groundwater system. A representation of the local groundwater system for the Alpha coal project, as given by URS Australia, is shown in Figure 4. An important addition to information was the final results of monitoring groundwater levels associated with the Alpha test pit, which operated from November 2010 to July 2011, with a montage of these results shown in Figure 5. The relatively flat head responses over time of most groundwater layers are used to infer that recharge is insignificant or minimal.

4.3.7 The updated URS Australia groundwater modelling study shows a slightly different regional groundwater flow schematic to the Alpha EIS – reproduced as Figure 6 herein – with no recharge to the Clematis and Colinlea sandstones, although there is still a local water table in the Alpha coal project area flowing east along topographic gradients. Furthermore, the reported groundwater heads from exploration bores (acknowledged to be a poor proxy for individual aquifers due to their open hole nature) and the D-E (lower Colinlea) sandstone, are reproduced as Figure 7.

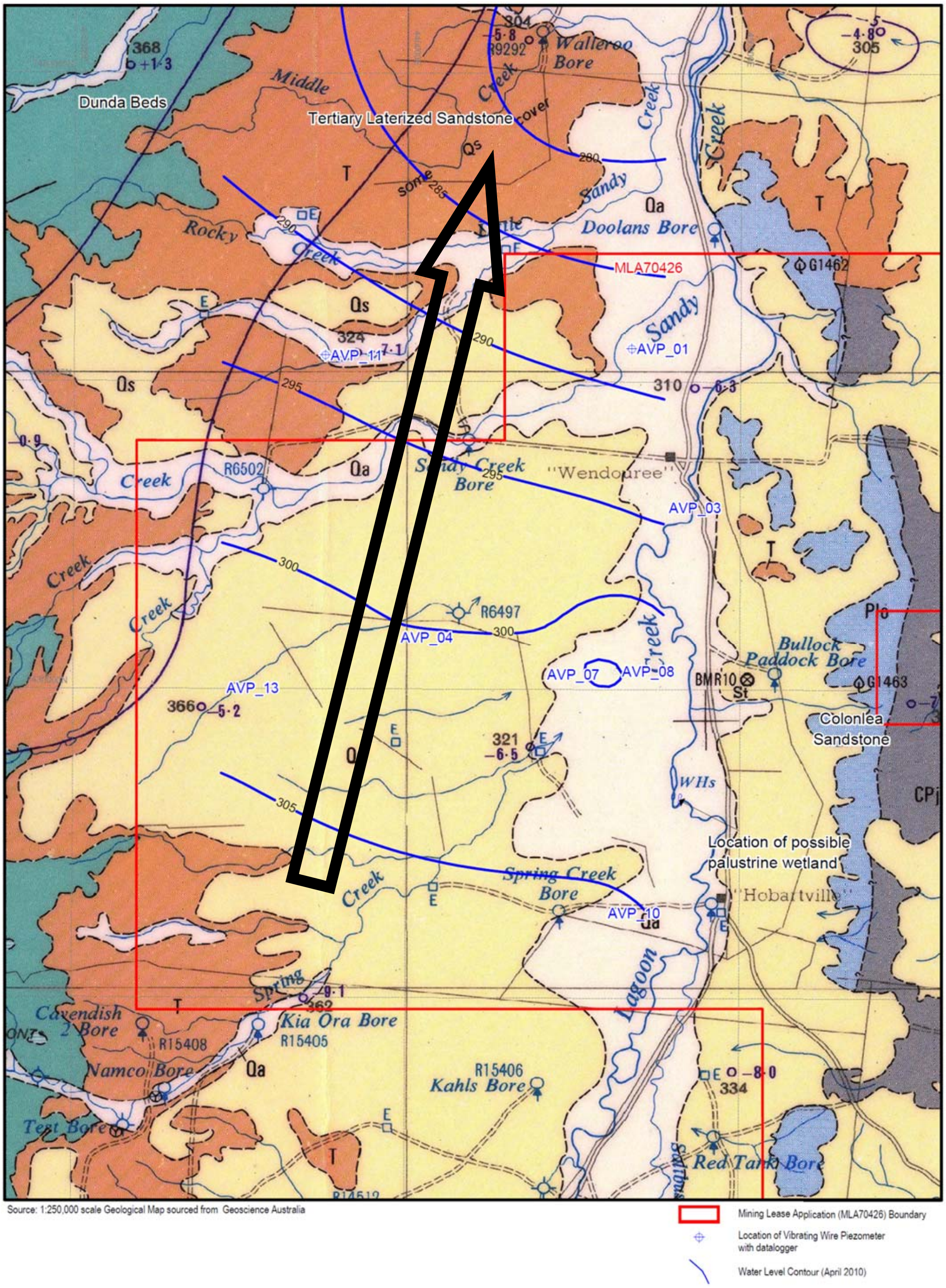

Figure 3: Groundwater heads in the D-E sandstone layer of the Colinlea sandstone, as given in the EIS (Volume 2, Section 12, Figure 12-7) (HP, 2010) (Note: large black arrow added)

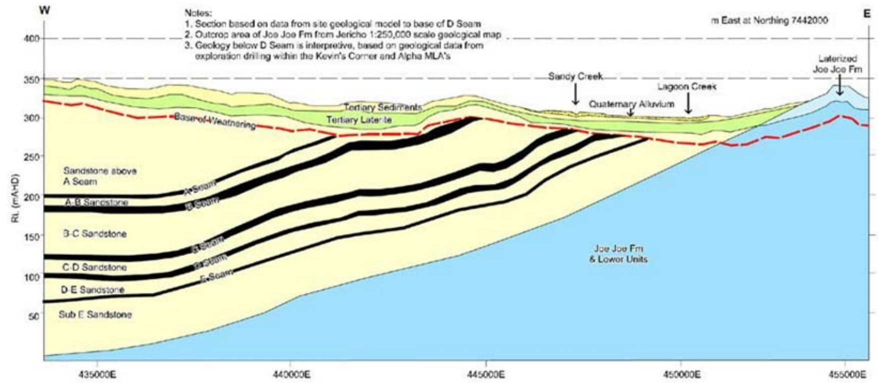

Figure 4: Conceptual representation of the local groundwater system for the Alpha coal project region as given in the URS Australia Report (Figure 4-9) (URS, 2012) (Note: image slightly edited for sharper presentation; no information changed)

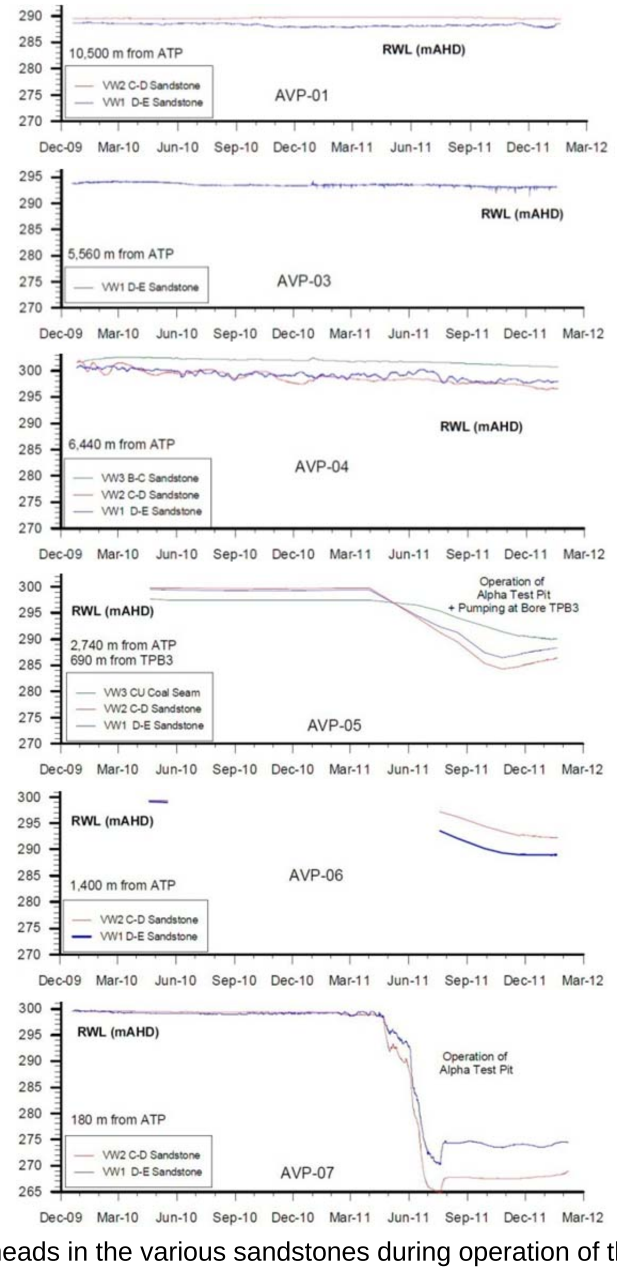

Figure 5: Groundwater heads in the various sandstones during operation of the Alpha test pit (Figures 4-15 & 4-16; URS, 2012) (Note: images slightly edited for spacing/sizing only to allow room to display on this single page; no data was changed)

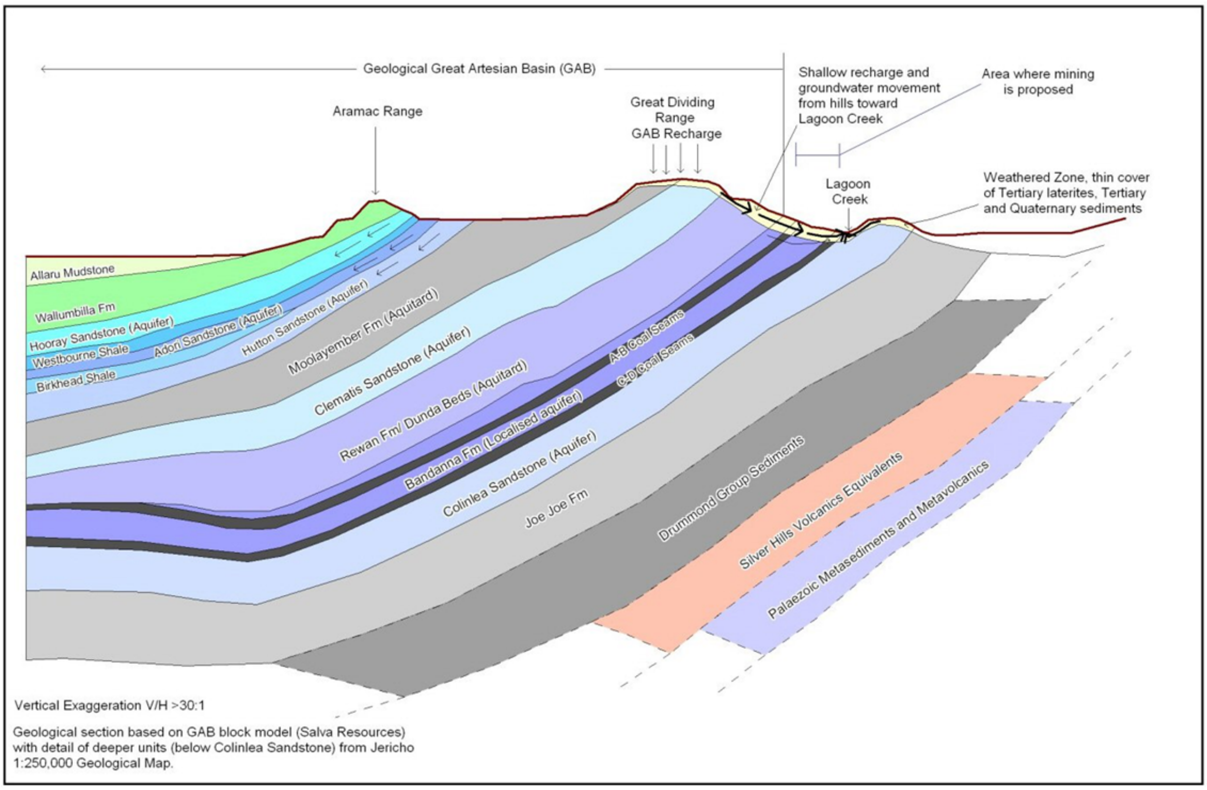

Figure 6: Regional conceptual geology of the Alpha coal project region as given in the updated URS Australia groundwater modelling study (Figure 4-11; URS, 2012)

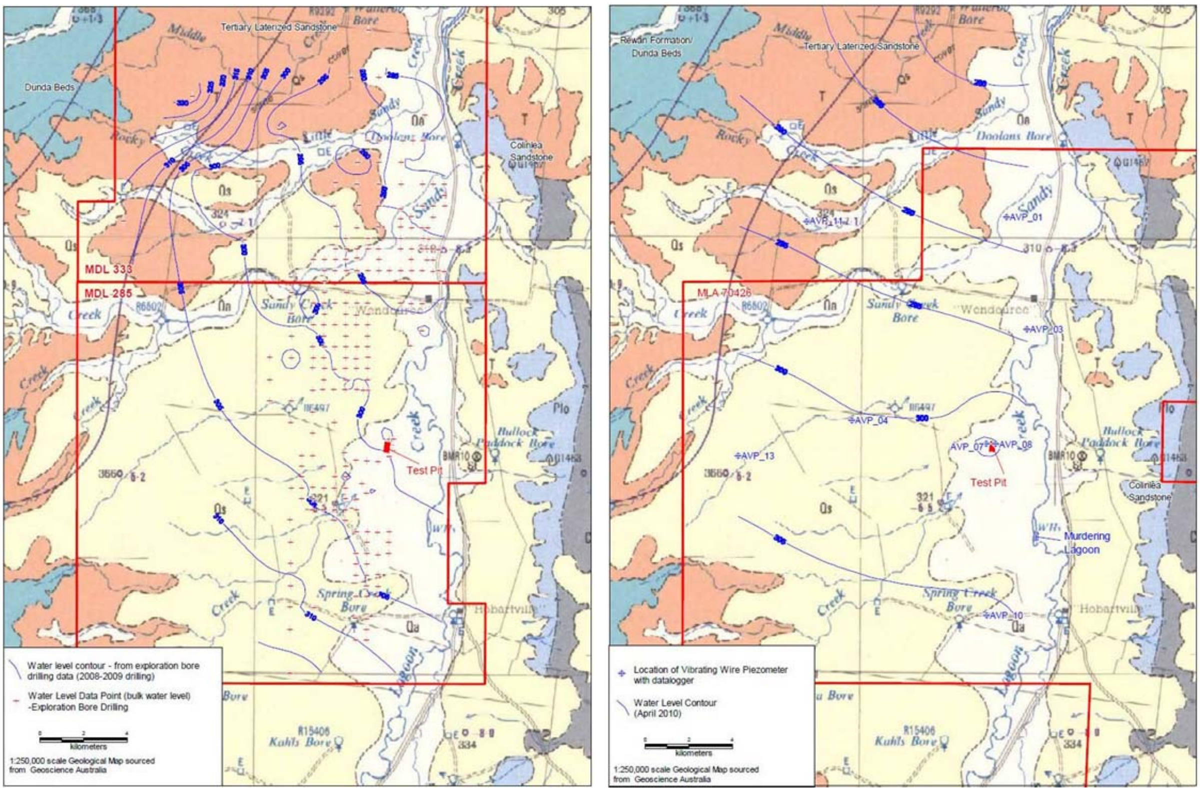

Figure 7: Groundwater heads (levels) of exploration bores at the Alpha coal project (left) and for the D-E (lower Colinlea) sandstone (right) (Figures 4-12 & 4-13; URS, 2012)

4.4 Inconsistencies and criticisms of the EIS representation of the local to regional groundwater system in the Alpha coal project region

4.4.1 As noted previously, it is contradictory to present the groundwater flow in regional diagrams as moving in a westerly direction and then present local flow in a north-easterly direction – this is physically impossible.

4.4.2 I have taken as reliable the measured head data (in URS, 2012 and earlier Alpha EIS reports), even allowing for the issues in measuring groundwater heads in open exploration bores. Part of the reason for this is the topography which slopes to the east away from the Great Dividing Range. It is reasonable to assume in groundwater that topography plays an important role in local groundwater flow directions.

4.4.3 On this basis, there has to be a physical control on groundwater heads to the west of the Alpha project area – yet the Alpha EIS, Supplementary EIS and URS Australia reports all fail to investigate this issue. There are three possible mechanisms: (i) a major recharge pathway in the Great Dividing Range which maintains elevated groundwater pressures; (ii) a surface water feature which maintains effectively constant water levels; or (iii) a geological control, perhaps subtle, which is not shown or acknowledged by Hancock Coal or URS Australia. Given the climatic conditions of the region, I do not believe that high recharge rates are a plausible explanation, plus there is no surface water feature providing a constant head. This leaves scenario (iii) – and given the geology, it is reasonable to expect that the processes which produced uplift in the Great Dividing Range also pushed up the Colinlea sandstones (and coal seams) locally along this axis, which thereby acts as a local structural control (or in geological terms, an 'anticline') on groundwater flow and forming an effective divide. Furthermore, given that the eastern side of the Great Dividing Range is mostly Rewan Formation, an effective low permeability aquitard, this suggests that there is also full hydrostatic pressure from the Clematis sandstone on the western side of the Great Dividing Range through the Rewan Formation to the underlying Colinlea sandstone. This re-interpretation of the local geological controls on groundwater heads and flow directions is supported by the regional topography, shown in Figure 8, which shows that the Great Dividing Range lies along a north-south line to the west of the Alpha project area, but moves to a north-west to south-east orientation south of the Capricorn Highway west of the township of Alpha. This topography and underlying geological structure provides the physical basis to explain the groundwater heads observed in the Alpha project area, as shown in Figure 7. Finally, the Waratah Galilee coal project EIS shows the conceptual presence of a geological fold structure coinciding with the Great Dividing Range, shown in Figure 9, further validating the view that it is geological structure which must be controlling the unusual north-east flowing groundwater pathways in the immediate region east of the Great Dividing Range.

4.4.4 In addition, in reviewing the South Galilee coal project EIS, this EIS presents some important information relating the changes in groundwater levels over time scales of a few decades through climatic conditions of dry and wet periods. The results, shown in Figure 10, demonstrate that wet periods (shown by an increase in the thick blue line) invariably lead to increases in both shallow and deeper groundwater heads – showing that active groundwater recharge is indeed occurring, despite Hancock/URS arguing it is very low to negligible, and that there is good hydraulic connection between the shallow and deeper aquifers (at least in the area of these bores – but given the similar geology of the region, this can be reasonably expected to apply elsewhere to a somewhat similar degree, depending on site specific factors).

4.4.5 In my opinion, the reason why the Alpha trial pit groundwater monitoring bores show no response to rainfall, unlike the bores near Alpha township, is that they are measuring the sandstone aquifers beneath the Tertiary laterite layer (see my Figure 4) – which is effectively a moderate to low permeability geological layer and this would act as a quasi-aquitard. That is, the infiltration rates through the surface soils and laterite are so slow that the water is evapotranspired before it can generate groundwater recharge to the underlying sandstone layers. Given that the monitoring bores are all located close to the Alpha test pit, and none are in areas of Colinlea or Clematis sandstone outcrop or subcrop, there are no bores for the Alpha coal project which are actually monitoring groundwater in areas where there would be a degree of active recharge occurring.

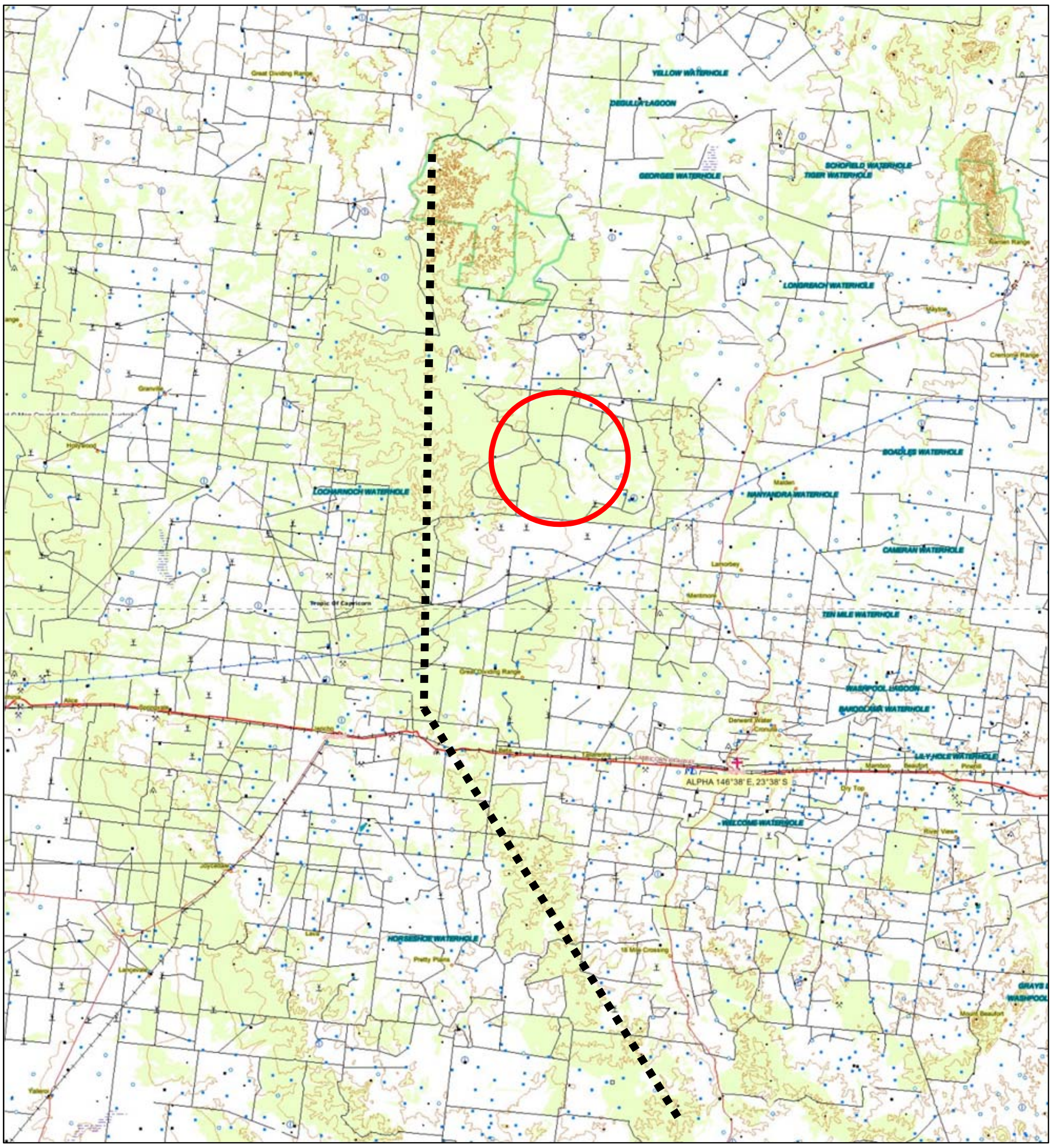

Figure 8: Regional topography showing the Great Dividing Range (approximately, as black dashed lines), with approximate location of Alpha coal project shown as red circle (adapted from MapConnect, 2013)

4.4.6 Overall, the Hancock/URS EIS studies fail to incorporate a rigorous approach to regional geological controls on groundwater heads, recharge processes and flows, thereby severely limiting any subsequent reliability in predictive numerical modelling and impact assessments.

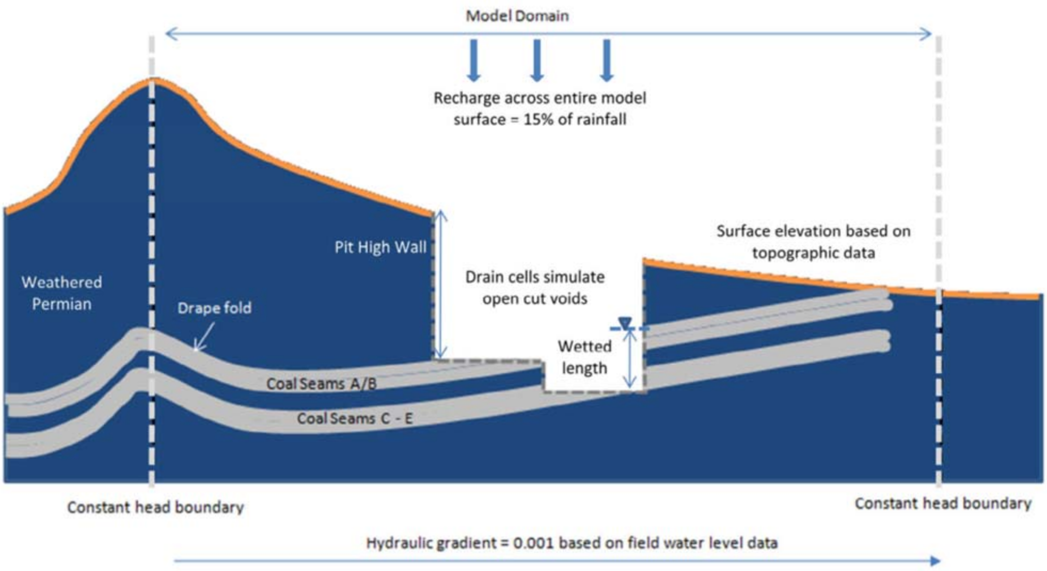

Figure 9: Regional conceptual geology of the Galilee coal project region as given in its EIS (Appendix 14, Figure 2-4; WC, 2011)

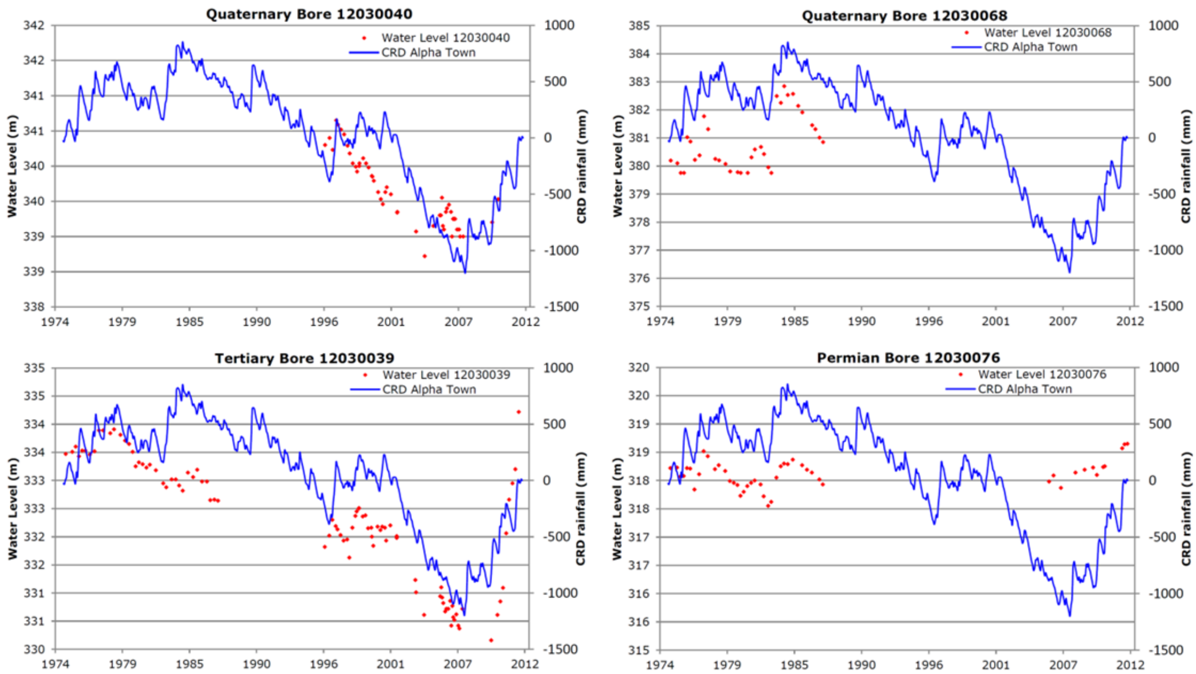

Figure 10: Groundwater heads (levels) versus cumulative rainfall deviation (CRD) from mean monthly rainfall for water table and deeper bores near Alpha township (from the South Galilee EIS) (Appendix G, Figure 4-4; AMCI, 2012)

4.5 Groundwater Recharge Rates

4.5.1 As part of reviewing the conceptual presentation of groundwater in the various EIS's, one of the most critical aspects (arguably as equally as important as geological structure) is the recharge or inflow rates to groundwater and aquifers. This issue has been partially examined in sections 4.3 and 4.4, and the following is worth noting with regards to the various coal project EIS's:

4.5.2 *Alpha and Kevin's Corner EIS's* (Hancock) – recharge rates are on average very low, perhaps around 3 mm/year, with episodic recharge during major rainfall periods above 200 mm in a single month. At 3 mm/year, this is ~0.6% of average annual rainfall.

4.5.3 *Galilee EIS* (Waratah) – for the numerical model, recharge rates were assumed to be 15% of average annual rainfall (see Appendix G) – although the evidence used to support such a high value is not clearly presented.

4.5.4 *South Galilee EIS* (AMCI) – based on a mass balance analysis method using chloride (Cl) concentrations in shallow groundwaters, recharge rates were estimated to be between 1 to 20 mm/year, or 1 to 4% of average annual rainfall (see Section 9.5.7.1).

4.5.5 ***My Comments*** – based on the relatively dry climate, whereby evapotranspiration is some four times annual rainfall (based on climate data in the various EIS's), it can reasonably be expected that annual average recharge rates would be very low, probably of the order of 1%, but individual major rainfall or flood events may lead to important recharge events for groundwater. This is evidenced by the groundwater level data near Alpha township given in the South Galilee EIS, provided herein as Figure 10, whereby the groundwater heads in both shallow and deeper aquifers rise and fall with the switch between dry to wet climatic periods. The inconsistency between the recharge rates of the various EIS's again raises concerns with respect to the rigour and thoroughness of this aspect of groundwater in the Alpha EIS.

4.6 Cumulative Impacts

4.6.1 Given the number of projects proposed for the eastern Galilee Basin and their potential scales, the cumulative environmental (and other) impacts from all projects are clearly a significant issue. The Alpha, Kevin's Corner, Galilee and South Galilee coal projects all included cumulative impacts in their EIS Terms of Reference (or Guidelines).

4.6.2 ***South Galilee EIS*** – this included some simplified scenarios regional for groundwater impacts from the Galilee, Alpha and Kevin's Corner coal projects, and addressed cumulative impacts through numerical modelling (Appendix G). The drawdowns in regional groundwater after 33 years of mining are shown in Figure 11.

4.6.3 ***Galilee EIS*** – this included a brief commentary on cumulative impacts to groundwater resources (amongst other aspects), noting that the combination of several large scale projects would lead to major risks of significant cumulative impacts. No numerical modelling is presented, and this is left for future work. It is argued that the effective implementation of mitigation and management measures should reduce risks of excessive cumulative impacts, such as long-term pumping tests, ongoing monitoring and make good agreements if required.

4.6.4 ***Alpha and Kevin's Corner EIS's*** – in general, the assessment of cumulative impacts only includes Alpha and Kevin's Corner and not Galilee or South Galilee, with a detailed numerical groundwater model presented by URS Australia after the Supplementary EIS. The URS Australia report only addresses cumulative impacts on groundwater in a very rudimentary and conceptual manner, and certainly not even using some simplified scenarios like the South Galilee EIS did to model Galilee, Alpha and Kevin's Corner. URS also argue that a combined numerical model of all projects is unrealistic due to differences in conceptual models, data quality, recharge rates, boundary controls, assumptions, and so on.

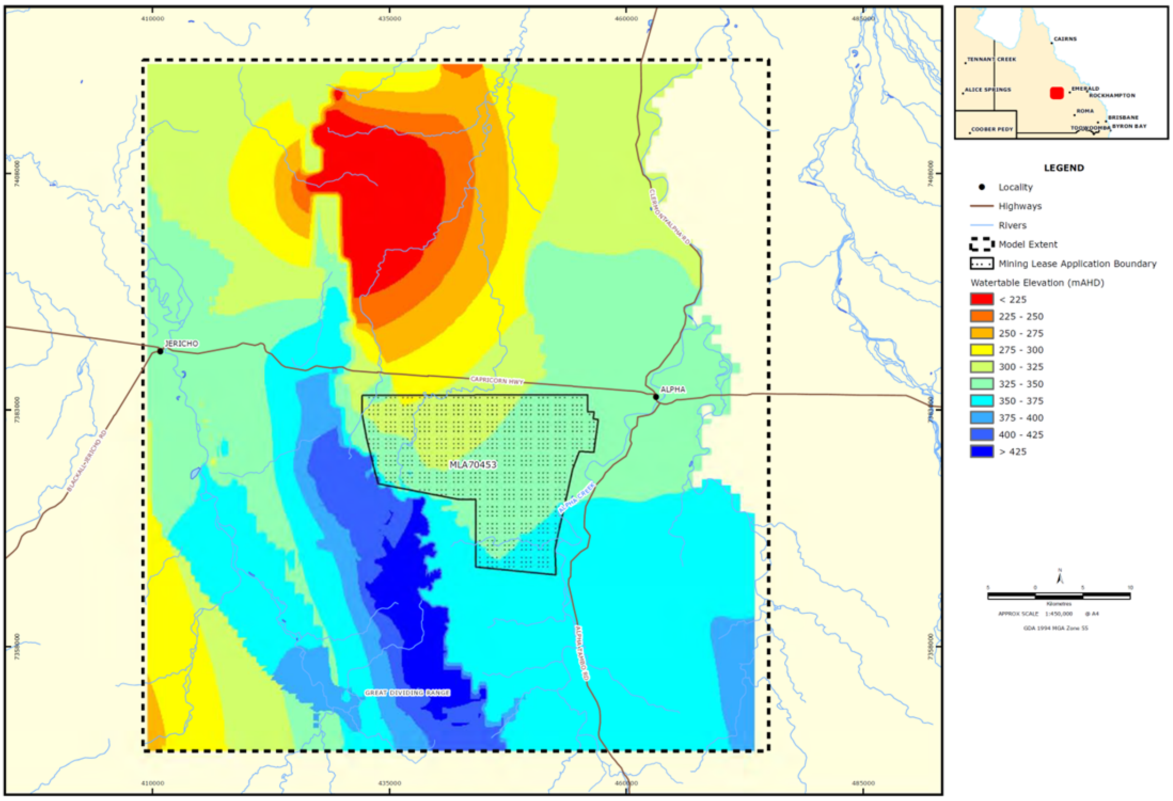

Figure 11: Groundwater drawdowns (reductions in heads) after 33 years as modelled for the South Galilee coal project (from the South Galilee EIS, Appendix G, Figure 7-2) (AMCI, 2012)

4.6.5 ***Interim Independent Expert Scientific Committee (IIESC)*** – the IIESC's advice to the Federal Environment Minister on the Alpha EIS studies noted that (20 July 2012):

".. the cumulative surface water and groundwater impacts in the region have not been assessed. Based on limited information presented, in particular, on cumulative impacts, the committee has considerable concerns relating to the scale and extent of impacts associated with the project. A regional cumulative impact assessment should be undertaken as a matter of priority."

4.6.6 ***Galilee Basin Operators Forum (GBOF)*** – GBOF is a joint effort by coal seam gas (CSG) companies exploring the Galilee Basin to co-operate on groundwater research and other potential issues (www.gbof.com.au). GBOF was formed in late 2010, and recently they released a detailed groundwater study of the Galilee Basin (RPS, 2013), which combines and assesses as much historical and company data to present a synthesized and holistic view of the groundwater resources and behaviour of the Galilee Basin. The study scale and focus is regional and basin-wide, limiting any potential use for comparison against the Alpha EIS local studies, but it clearly demonstrates that companies can indeed co-operate – in this case, even before exploration has proceeded to the point of commercial projects being proposed.

4.6.7 Overall, the failure of the Hancock/URS EIS studies to adopt a rigorous approach to regional cumulative impacts from the several proposed projects is, in my view, a failure to meet the EIS Terms of Reference.

4.7 Water Quality Issues

4.7.1 There are three primary water quality issues raised in the Alpha EIS, Supplementary EIS and URS Australia modelling report – pit water quality over time, seepage into shallow groundwater from tailings storage facility and acid mine drainage risks from mine wastes.

4.7.2 *Pit water quality over time* – this is modelled by the URS Australia report (URS, 2012) and presented in Section 12.8, with Figures 12-8 to 12-10 showing the continually increasing salinity in the pit lake over time for variable runoff TDS concentrations. After 300 years, ranging from 5,800 mg/L (runoff TDS 50 mg/L) to 15,500 mg/L (runoff TDS 200 mg/L), with the salinity still increasing in all runoff TDS scenarios. In this modelling, no allowance has been made for variable climatic conditions or climatic changes over time (eg. higher temperatures and evaporation rates). Furthermore, no assessment has been made of likely heavy metal concentrations over time or other potential toxic elements or compounds (eg. organics derived from coal). There is also no reference made to other similar studies on pit lake evolution to justify the model assumptions and structure, limiting confidence in the model results. Finally, there was no attempt to investigate how long it will take for the pit lake to reach an equilibrium or stable salinity – is this 500 or 1,000 years or longer?

4.7.3 *Seepage from the tailings storage facility (TSF)* – this is modelled by the URS Australia report (URS, 2012) and presented in Section 13.5, with Figure 13-8 showing the extent of seepage impacts after 300 years, as measured by salinity (TDS), given here as Figure 12. Although the report states that “no impact to Lagoon Creek is predicted during the simulation” (page 159) – this is only due to the fact that the model stops at 300 years despite the clear evidence of extensive seepage which has almost reached Lagoon Creek (see Figure 12 below and note the interaction of Lagoon Creek with shallow groundwater as shown by Figure 2 previously). If the model run time was extended, it would only be a short period of time (I would conservatively expect an extra 50 years would be sufficient) before there would be breakthrough of TSF seepage to Lagoon Creek. Remarkably, the report even goes on to state that “limited risk to Lagoon Creek and sub-E sandstone (aquifer) units are predicted” (page 160) – despite a considerable extent of the sub-E (ie. lower Colinlea) sandstone being severely impacted by TSF seepage with TDS concentrations reaching 10,000 mg/L or nearly ten times higher than average background groundwater salinity. There is minimal discussion of the variety of complex parameters required for modelling solute transport in groundwater (eg. porosity, dispersion, diffusion, etc.), especially the respective field basis for such values. There is no mention of the possibility of seepage-affected shallow groundwater impacting on deep rooted vegetation. For flow rates, it is also unlikely that the TSF will maintain saturated conditions after rehabilitation, given the dry climate, yet this change from saturated to unsaturated soil conditions is ignored in the modelling. Finally, despite the pit lake increasing in salinity over time due to evaporative effects from the dry climate, no such allowance has been made for the TSF, whereby similar processes would lead to increasing salinity in the TSF over time (no discussion is provided on the effects of eventual rehabilitation on the TSF and its salinity over time either). Overall, this modelling work is very simplistic and, despite its shortcomings, clearly shows that extensive and effectively permanent impacts can be expected from TSF seepage to groundwater and that these impacts will eventually reach the creeks with possibly significant implications for surface water quality and ecosystems.

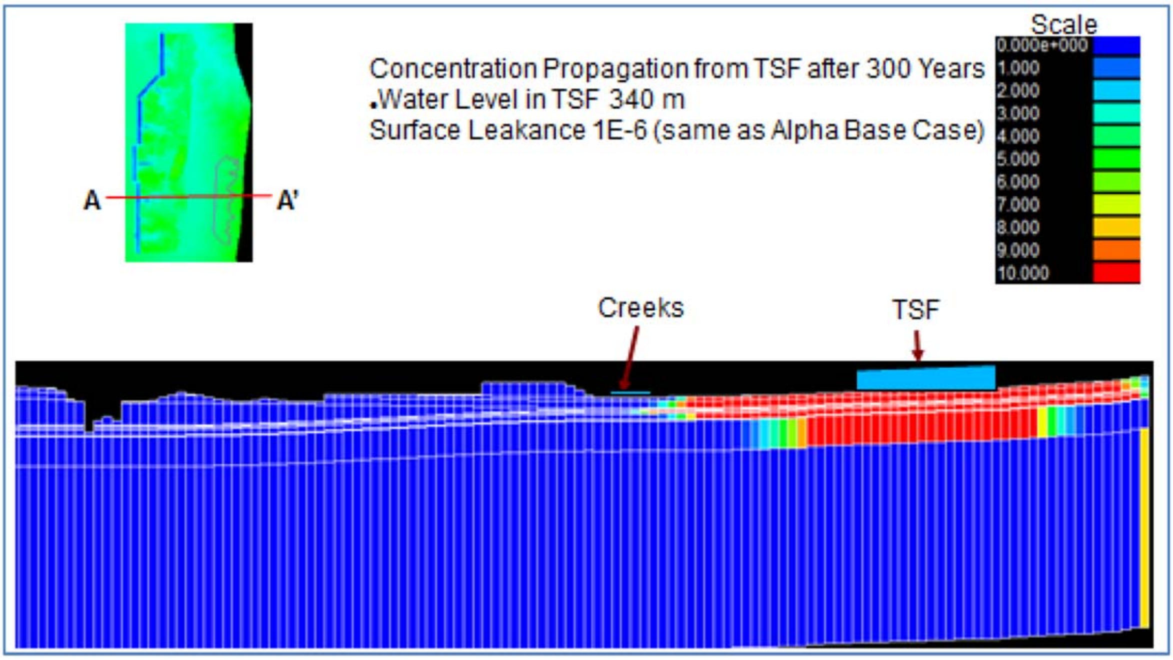

Figure 12: Seepage impacts from the tailings storage facility after 300 years, as measured by salinity (TDS) (Figure 13-8) (URS, 2012)

4.7.4 *Acid mine drainage risks* – acid mine drainage (AMD) occurs when sulfidic materials (especially pyrite or iron sulfide) are exposed in the surface environment to abundant water and oxygen. AMD can cause severe impacts to aquatic ecosystems due to extreme concentrations of acid, salts and heavy metals. In my opinion, the assessment of AMD risks by the EIS and Supplementary EIS suggests it is a relatively low risk compared to TSF seepage and pit lake salinity, provided that Hancock are very diligent in their monitoring and assessment of sulfidic materials should they proceed with project development and operations. However, should Hancock fail to manage AMD risks pro-actively, AMD risks could present a severe risk from mine waste piles, TSF seepage or possibly to pit lake water quality.

5. Question 2.2: Do I agree with the Coordinator-General's assessment in relation to groundwater?

5.1 The Coordinator-General (CG) addresses groundwater impacts in Section 5.7 of his assessment report on the Alpha EIA process (Broe, 2012). While some conditions are extensive, the report fails to identify the substantive issues with the groundwater investigations and modelling I have discussed in my report. Specific comment is as follows:

5.1.1 *Groundwater modelling* – the CG's requirement is to regularly update and re-calibrate the regional groundwater model, initially every 3 years (though how many times at 3 year intervals is not specified) and then every 5 years. The requirement to make the model available to other projects to facilitate more comprehensive cumulative impact assessment is also good, though there is no discussion or recognition of the failure of the Alpha EIS, Supplementary EIS and URS Report to address cumulative groundwater impacts from all proposed coal projects in the region.

5.1.2 *Existing groundwater users* – the recognition that further work is required to address groundwater security for existing users is welcome, though this is, in some ways, contrary to the CG's positive comments on the groundwater modelling. Furthermore, there seems to be no recognition of the long-term impacts of drawdown from the open pit or from TSF seepage impacts on groundwater salinity – especially both of these impacts on the sub-E (Colinlea) sandstone which is a prime consideration for a replacement groundwater bore under any make good agreement. There is no appreciation of the uncertainty involved in predicting groundwater impacts, and how this could lead to a situation where the Alpha project causes irreversible impacts on groundwater and they are unable to provide an alternative groundwater supply for existing users.

5.1.3 *Great Artesian Basin risks* – the CG's report fails to recognise that the URS modelling study effectively assumed the Rewan Formation of the GAB as a constant head boundary and, therefore, arguing that the modelling shows no impacts on the Clematis Sandstone (or Rewan Formation also) is non-sensical – by defining the boundary condition in this way, it automatically builds in no impacts. As per my previous comments on the geological controls on groundwater levels in the Alpha area, it is clear that the local folding underneath the Great Dividing Range is a locally significant control for groundwater flow to the east, but it is not clear based on field evidence that the assumption of no substantive flow through the Rewan Formation is valid – and this is supported by the comments by RPS and SEWPaC and noted by the CG's report (pages 66-67). While I agree that risks to the GAB Clematis sandstone aquifer are low, given the large scale of the Alpha coal project (plus all other projects), it is scientifically reasonable to expect more than assumption and expectation in assessing the potential impacts. The CG's requirements for further monitoring, especially cumulative impacts, are welcome, although there is a need to be more specific in the location and number of bores.

5.1.4 *Appendix 1, Schedule 2, Condition 17 Groundwater* – these conditions are generally excellent, although a more explicit requirement for more regional bores could be stated to ensure that a minimum number of bores monitoring aquifers such as the Clematis or deeper Colinlea sandstones. To facilitate stakeholder engagement and community consultation and groundwater management in the region, a new condition could be added to make the annual reports easily publicly available (eg. via the internet). In addition, specific clarity could be provided in the definition of 'monthly until sufficient data is compiled' – how will this be determined?

5.1.5 *Appendix 2, Part B, Condition 2 Groundwater* – the emphasis on a regional and basin-wide groundwater model is excellent and will facilitate more comprehensive assessments of cumulative impacts should all other coal projects proceed. In addition, the annual public release of monitoring data is welcomed.

5.1.6 *Appendix 3, Part B, Recommendation 3* – the focus on comparing modelled results with actual monitoring is excellent and will ensure that the technical quality of the model continues to improve over time as further data becomes available (especially the additional groundwater studies and aspects noted in my report).

6. Question 2.3: Is there a need for further studies before approval?

6.1 In my view, YES. Based on the various deficiencies I have identified in the EIS and related studies, a variety of studies should be undertaken to improve understanding of local and regional geology, especially as this relates to controls on groundwater recharge, heads and flow directions, and using this information to improve the numerical groundwater model and facilitate more informed impact assessments for make good agreements. In addition, with the improved groundwater studies, a more comprehensive approach could be developed to rigorously assess cumulative groundwater impacts from all proposed projects in the region.

7. Question 2.4: adequacy of baseline groundwater studies for the Alpha project

7.1 The groundwater aspects in the Terms of Reference (ToR) for the Alpha EIS were specified by the Coordinator-General in section 3.4.2, and included (in summary): existing groundwater supplies (including location, type, drawdown, recharge rates, seasonal variations), geology, aquifers (type, depth, thickness, transmissivity), aquifer interconnectivity, depth to groundwater levels (ie. pressures), groundwater flow directions, surface water interaction, existing and possible sources of recharge, and vulnerability to pollution and water quality/geochemistry.

7.2 In general terms, based on my experience of reviewing numerous EIS studies for other mining projects in Australia and internationally, the amount of groundwater studies completed for the proposed Alpha coal project was extensive. Based on the paraphrased CG's list above in 7.1, many of these aspects are addressed (eg. aquifers, type, depth, transmissivity, etc). However, in my view, it is not simply the volume of work which is of prime importance – it is the quality and scientific accuracy of these studies which remains paramount. As noted throughout previous sections of my report, I have identified a range of errors and poorly justified assumptions which, in my view, lead to an inaccurate baseline assessment of groundwater for the Alpha project. These inadequacies also have significant implications for assessing the potential cumulative effects on groundwater resources from all proposed coal projects in the eastern Galilee Basin region (Alpha, Kevin's Corner, Galilee, South Galilee).

8. Question 2.5: potential drawdown from the Alpha project or cumulative effects with other proposed projects

8.1 In my view, the incorrect boundary conditions assumed in the latest groundwater modelling by URS Australia (URS, 2012) limit my confidence in the predictions of drawdown in groundwater due to the proposed Alpha project, and especially cumulative effects from all proposed coal projects in the region (should they proceed). In order to arrive at a view, further field work is required to address the shortcomings I have outlined in this report and then re-developing and re-running the groundwater model to account for the revised boundary conditions, especially the western side along the Great Dividing Range and with all proposed projects to more rigorously assess the potential long-term groundwater impacts from possible coal mining in this region.

9. Question 2.6: any impact that the proposed Alpha coal mine's groundwater drawdown or potential contamination may have on the Great Artesian Basin.

9.1 At present, in my view, I can conceive of a mechanism or process that could – theoretically at least – lead to drawdown impacts on the Clematis sandstone of the Great Artesian Basin. The elevated groundwater levels along the Great Dividing Range must be derived from the higher stratigraphic position (ie. elevation or height) of the Clematis sandstone – with this hydraulic pressure transmitted through the Rewan Formation to the underlying Colinlea sandstone units (and hence the elevated groundwater levels in the Colinlea sandstone aquifers on the eastern side of the divide despite the generally westerly dipping basin formations). As the groundwater drawdown from the Alpha coal mine expands regionally (should the project proceed), it will reach to the west and, rather than the Great Dividing Range acting as a constant head, the groundwater pressures will decline in the Colinlea sandstone, causing a downwards hydraulic gradient through the Rewan Formation and subsequently a low rate of groundwater flow through the Rewan Formation and drawdown in the Clematis sandstone. Given the time it would take for the regional drawdown from the Alpha project to develop (several years or more as mining expands) and the low permeability of the Rewan Formation, this mechanism could be expected to take at least a decade (or much longer) to observe. Unfortunately, in my view, the information presented in the Alpha and other EIS's does not facilitate the development of a reasonable numerical groundwater model, even if conceptual in nature, of the above mechanism and process.

9.2 At present, based on the geology of the eastern Galilee Basin as presented in the various EIS's (Alpha, Kevin's Corner, Galilee, South Galilee), in my view there is extremely limited potential for contamination of water quality of the Clematis sandstone of the Great Artesian Basin – unless drawdown effects started to occur and induce changes in the geochemistry and water quality. The primary issue remains drawdown, although ongoing water quality monitoring should be undertaken to confirm this (if the Alpha project and others proceed).

10. Question 2.7: are there any issues that should be examined in more detail or additional lines of inquiry that should be undertaken in relation to groundwater before an approval is granted?

10.1 In my view, YES. I outlined my view in 6.1 previously.

11. Confirmation

I confirm that:

11.1 the factual matters stated in the report are, as far as I know, true; and
11.2 I have made all enquiries considered appropriate; and
11.3 the opinions stated in the report are genuinely held by myself; and
11.4 the report contains reference to all matters I consider significant; and
11.5 I understand the duty of an expert to the court and have complied with that duty.

Signed

…… …… 30 June 2013
(Dr Gavin M. Mudd)

12. References

AMCI, 2012, *South Galilee Coal Project Environmental Impact Statement*. AMCI (Alpha) Pty Ltd and Alpha Coal Pty Ltd, Brisbane, QLD, October 2012.

Broe, B, 2012, *Alpha Coal Project – Coordinator-General's Evaluation Report on the Environmental Impact Statement*. The Coordinator-General, Queensland Government, Brisbane, QLD.

HP, 2010, *Alpha Coal Project Environmental Impact Statement – 6 Volumes*. Hancock Prospecting Pty Ltd (HP), Brisbane, QLD.

HP, 2011, *Alpha Coal Project Supplementary Environmental Impact Statement – 2 Volumes*. Hancock Prospecting Pty Ltd (HP), Brisbane, QLD.

MapConnect, 2013, *Topographic Mapping – MapConnect Online Service*. Geoscience Australia, Canberra, ACT, www.ga.gov.au/topographic-mapping/mapconnect.html (Accessed 21 June 2013).

URS, 2012, *Groundwater Modelling Report – Alpha Coal Project*. Prepared by URS Australia Pty Ltd for Hancock Prospecting Pty Ltd (HP), Brisbane, QLD, March 2012.

WC, 2011, *Environmental Impact Statement – Galilee Coal Project; 5 Volumes*. Waratah Coal Ltd (WC), Brisbane, QLD.

13. Annexure A: Curriculum Vitae – Dr Gavin M. Mudd

Dr Gavin M Mudd

Brief Curriculum Vitae: June 2013

Current Position

Senior Lecturer / Course Director – Environmental Eng.
Department of Civil Engineering
Monash University, Clayton, VIC
Ph (03) 990 51352 – Mobile 0419 117 494
Email: Gavin.Mudd@monash.edu

Dr Gavin M Mudd has been an active researcher on the environmental impacts and management of mining for over a decade. He has been involved with many aspects of the mining industry with a particular specialty in sustainability in mining, uranium mining, groundwater, environmental impact assessment and environmental management. Gavin maintains an independent perspective, and has undertaken research for community groups, aboriginal organisations and mining companies. In particular, Gavin has had extensive involvement in examining the underlying scientific issues associated with uranium mining in Australia, with detailed knowledge of the Australian uranium mining sector as well as globally. With strong qualifications and experience, he has developed a unique understanding of the multidisciplinary nature of the environmental aspects of mining in Australia and globally, culminating in a distinctive view on how to quantify an apparent oxymoron – that of "sustainable mining". Additionally, Gavin has active research interests in urban groundwater issues, groundwater management and assessment, especially with respect to climate change and sustainability.

Qualifications

Doctorate (PhD) Victoria University of Technology (awarded Oct. 2001)
B. Env. Eng. (Hons) RMIT University (awarded May 1995)

Current and Previous Appointments

- January 2011 to present – **Senior Lecturer/Course Director in Environmental Engineering**, *Civil Eng*, *Monash University*, including a wide range of teaching, research and administration.
- November 2009 to February 2010 – **Visiting Fellow**, Institute of Environmental Studies, University of New South Wales, Sydney
- July to October 2009 – **Visiting Fellow**, Dept of Civil & Environmental Eng, University of Auckland, New Zealand
- January 2006 to December 2010 – **Lecturer/Course Director in Environmental Engineering**, *Civil Eng*, *Monash University*, including a wide range of teaching and research.
- May 2003 to December 2005 – **Assistant Lecturer in Environmental Engineering**, *Civil Eng*, *Monash University*, including a wide range of teaching, research and administration.
- Approximately 20 months **consulting experience** - contaminated sites, environmental assessment, groundwater, solute transport and unsaturated flow modelling, laboratory testing of mine wastes, liaison with government and industry organisations, working with and for Aboriginal people.
- July 2000 to April 2002 - **Research Fellow in Mine Waste Hydrology**, *Civil Eng*, *University of Queensland* - theoretical studies, laboratory testing and modelling of mine wastes and tailings, student research supervision, lecturing in geomechanics.
- March to July 1998 (Semester One) - **Lecturer in Earth Sciences/Geomechanics**, Victoria Uni.
- March 1995 to June 2000 - **PhD Research** - groundwater geochemistry, solute transport modelling, field studies of coal ash leachability, modelling of leaching, unsaturated flow and evaporation processes in ash disposal.

Professional Memberships

- Sustainable Engineering Society (**SEng**, part of
- International Association of Hydrogeologists (**IAH**)

Engineers Australia)
- Society of Economic Geologists (**SEG**) (Member)
- Australasian Institute of Mining and Metallurgy (**AusIMM**) (Member)
- International Society for Industrial Ecology (**ISIE**) (Member)

Research Interests

- **Sustainable Mining** – environmental impacts, geochemistry, leachability & management of mine wastes, acid mine drainage, sustainability frameworks, life cycle assessment, modelling, sustainable resource management.
- **Groundwater** – groundwater management & sustainability, groundwater impacts from mining, modelling.

Research Grants & Involvement (Recent and Current)

- **CSIRO Minerals Futures Cluster** – joint CSIRO-university initiative, led by Institute for Sustainable Futures at UTS, the project is exploring the concept of 'peak minerals' and related issues. *(Project completed, 2009-2012)*
- **Institute for Sustainable Water Resources (ISWR)** – aquifer storage & recovery (ASR) and groundwater geochemistry in alluvial aquifers of Melbourne. *(Project completed, 2004-2008)*
- **Facility for Advancing Water Biofiltration (FAWB)** – urban water biofilters. *(Project completed, 2007-2009)*
- **eWater CRC** – groundwater-surface water interaction project. *(Involvement completed, 2006-2009)*

Post-Graduate Research Supervision

- **2 PhD students and 1 Masters** completed as principal supervisor, **2 PhD students** completed as co-supervisor; 2 Masters students currently as main supervisor, 1 PhD student as co-supervisor.

Publications

- **1 edited conference proceedings, 14 book and encyclopaedia chapters, 47 journal papers, 50 refereed and 52 non-refereed conference papers and presentations, and 25 major research reports or handbooks**, with numerous conference/journal papers, research reports and book chapters under review or nearing completion.

Undergraduate Teaching

- **Environmental Engineering** – Environmental Engineering (ENE1621) Environmental Impact Assessment & Management Systems (ENE3608), Environmental Risk Assessment (ENE4607), Research Projects (ENE4603/4).
- **Guest Lectures** – 1st Year Environmental Science (ENV1022), CIV3248, ENG1061.
- **Previously Taught** – Groundwater & Environmental Geoengineering (CIV3248; from 2004 to 2011), Energy & the Environment (ENE3048, 2007, ongoing minor role).

University Administration

- **Course Director – Environmental Engineering** (BEnvEng, BEnvEng/BSci, BEnvEng/BArts, BEnvEng/BComm)
- **Double Degree Adviser** – BEng/BSci, BEng/BComm, BEng/BArts, BEng/BLaw (for Civil/Env Eng)
- **University** – Carbon Management Committee
- **Faculty of Engineering – Academic Progress Committee (APC)**

Awards

- **Department of Civil Engineering's Award for Excellence in Teaching (2012)**, Monash University
- **Faculty of Engineering Dean's Award for Excellence in Teaching (2012)**, Monash University
- **Vice Chancellor's Citation for Outstanding Contribution to Student Learning (2011)**, Monash University

External Committees

- **Present** (September 2009 to present) – **Alligator Rivers Region Technical Committee (ARRTC)**, environment representative, national committee overseeing research on environmental aspects of uranium mining in the Alligator Rivers Region of the Northern Territory.
- **Prior** (Nov 2006 to Nov 2010) – **Society for Sustainability and Environmental Engineering (Victorian Branch)** – Victorian committee of national society, part of Engineers Australia.
- **Prior** (May 2004 to Dec 2006) – **Great Artesian Basin Co-ordinating Committee (GABCC)** – national inter-governmental committee for oversight of groundwater management of the GAB.

External Consulting

- **Uranium Mining** – pro-active role in providing detailed technical review and advice on uranium mining issues in the Kakadu National Park world heritage area (Ranger, Jabiluka), and globally (eg. Malawi, USA, Canada).
- **General Mining** – as requested, providing technical advice on environmental issues and mining (eg. gold mining in WA, Indonesia and Papua New Guinea; copper heap leaching; mineral sands mining; existing and proposed coal mining; coal seam gas).
- **Groundwater** – as requested, providing technical advice on groundwater chemistry and impacts from mining or other sites (eg. coal seam gas), groundwater resources and management.
- **Environmental Impact Assessment** – providing technical advice on EIA processes, critiquing EIS's.

Post-Graduate Theses Supervised (Principal Supervisor)

Kabir, M, 2011, *Long-Term Impact Study for Climate Change in the Shallow Unconfined Groundwater Recharge in Ranger Uranium Mine*. **Doctor of Philosophy (PhD)**, February 2011.

Klaas, D K S Y, 2009, *Indigenous Water Management: Sustainable Water Conservation Strategies in Karstic Dominated Area in Rote Island, NTT Province, Indonesia*. **Master of Engineering Science (MEngSci)**, August 2009.

Wendelborn, A, 2008, *Zinc and Copper Behaviour During Stormwater Aquifer Storage and Recovery in Sandy Aquifers*. **Doctor of Philosophy (PhD)**, December 2008.

Post-Graduate Theses Supervised (Co-Supervisor)

Browne, D C, 2011, *Predicting the Performance of Stormwater Infiltration Systems*. **Doctor of Philosophy (PhD)**, July 2011.

Thapa, K, 2009, *An Investigation on Dewatering Properties of Lignite Conditioned Digested Sewage Sludge*. **Doctor of Philosophy (PhD)**, Department of Chemical Engineering, July 2009.

Publications – Books and Conference Proceedings

1. **Mudd, G M** (Chief Editor), 2009, *Proceedings – Solutions for a Sustainable Planet: SSEE International Environmental Engineering Conference*. Society for Sustainability and Environmental Engineering (SSEE), Engineers Australia, Melbourne, VIC, November 2009.

Publications – Book & Encyclopaedia Chapters

1. **Mudd, G M** & Weng, Z, 2012, *Base Metals*. In "Materials for a Sustainable Future", Editors T Letcher, M G Davidson & J L Scott, Royal Society of Chemistry, UK, pp 11-59.
2. **Mudd, G M**, 2012, *Platinum Group Metals*. In "Materials for a Sustainable Future", Editors T Letcher, M G Davidson & J L Scott, Royal Society of Chemistry, UK, pp 119-151.
3. **Mudd, G M**, 2012, *Uranium*. In "Materials for a Sustainable Future", Editors T Letcher, M G Davidson & J L Scott, Royal Society of Chemistry, UK, pp 175-211.
4. **Mudd, G M**, 2012, *Gold*. In "Berkshire Encyclopedia of Sustainability, Volume 4 of 10: Natural Resources and Sustainability", Editors S Fredericks, L Shen, S Thompson, D Vasey, Berkshire Publishing, USA, pp 184-186.
5. **Mudd, G M**, 2012, *Iron Ore*. In "Berkshire Encyclopedia of Sustainability, Volume 4 of 10: Natural Resources and Sustainability", Editors S Fredericks, L Shen, S Thompson, D Vasey, Berkshire Publishing, USA, pp 253-254.
6. **Mudd, G M**, 2012, *Lead*. In "Berkshire Encyclopedia of Sustainability, Volume 4 of 10: Natural Resources and Sustainability", Editors S Fredericks, L Shen, S Thompson, D Vasey, Berkshire Publishing, USA, pp 256-257.
7. **Mudd, G M** & Mohr, S, 2012, *Lithium*. In "Berkshire Encyclopedia of Sustainability, Volume 4 of 10: Natural Resources and Sustainability", Editors S Fredericks, L Shen, S Thompson, D Vasey, Berkshire Publishing, USA, pp 261-262.
8. **Mudd, G M**, 2012, *Mineral Sands*. In "Berkshire Encyclopedia of Sustainability, Volume 4 of 10: Natural Resources and Sustainability", Editors S Fredericks, L Shen, S Thompson, D Vasey, Berkshire Publishing, USA, pp 286-287.
9. **Mudd, G M**, 2012, *Nickel*. In "Berkshire Encyclopedia of Sustainability, Volume 4 of 10: Natural Resources and Sustainability", Editors S Fredericks, L Shen, S Thompson, D Vasey, Berkshire Publishing, USA, pp 334-335.
10. **Mudd, G M**, 2012, *Platinum Group Metals*. In "Berkshire Encyclopedia of Sustainability, Volume 4 of 10: Natural Resources and Sustainability", Editors S Fredericks, L Shen, S Thompson, D Vasey, Berkshire Publishing, USA, pp 378-380.
11. **Mudd, G M**, 2012, *Silver*. In "Berkshire Encyclopedia of Sustainability, Volume 4 of 10: Natural Resources and Sustainability", Editors S Fredericks, L Shen, S Thompson, D Vasey, Berkshire Publishing, USA, pp 432-433.

12. **Mudd, G M**, 2010, *Uranium*. In "Green Energy: An A-to-Z Guide", Editor D Mulvaney, Sage Publishing, USA.
13. **Mudd, G M**, 2008, *Mining*. In "Ten Commitments – Reshaping the Lucky Country's Environment", Editors D Lindenmayer, S Dovers, M Harriss, S Morton, CSIRO Publishing, Collingwood, VIC, Chapter 16, pp 113-118.
14. **Mudd, G M**, 2001, *Nuclear Waste – The Great Victoria Desert, South Australia*. Australia Beyond Any Price, By Peter McConchie, Pan Macmillan, Sydney, NSW, Editor - Chapter 8, pp 96-105.

Publications – Journal Papers (peer reviewed)

1. **Mudd, G M**, Turnbull, I D, Graedel, T E & Weng, Z, 2013, *Quantifying the Recoverable Resources of By-Product Metals: The Case of Cobalt*. **Ore Geology Reviews**, In Press.
2. **Mudd, G M**, 2013, *The "Limits to Growth" and 'Finite' Mineral Resources: Re-visiting the Assumptions and Drinking From That Half-Capacity Glass*. **International Journal of Sustainable Development**, In Press.
3. Yellishetty, M, **Mudd, G M** & Shukla, R, 2013, *Prediction of Soil Erosion From Waste Dumps of Opencast Mines and Evaluation of Their Impacts on the Environment*. **International Journal of Mining, Reclamation & Environment**, In Press.
4. Browne, D, Deletic, A, **Mudd, G M** & Fletcher, T D, 2013, *A Two-Dimensional Model of Hydraulic Performance of Stormwater Infiltration Systems*. **Hydrological Processes**, In Press.
5. Jowitt, S, **Mudd, G M** & Weng, Z, 2013, *Hidden Mineral Deposits in Cu-Dominated Porphyry-Skarn Systems: How Resource Reporting can Occlude Important Mineralization Types Within Mining Camps*. **Economic Geology**, 108 (5), pp 1185-1193.
6. **Mudd, G M**, Weng, Z & Jowitt, S M, 2013, *A Detailed Assessment of Global Cu Reserve and Resource Trends and Worldwide Cu Endowments*. **Economic Geology**, 108 (5), pp 1163-1183.
7. Giurco, D, Mohr, S, **Mudd, G M**, Mason, L & Prior, T, 2012, *Resource Criticality and Commodity Production Projections*. **Resources**, 1 (1), doi:10.3390/res10x000x.
8. Northey, S, Haque, N & **Mudd, G M**, 2012, *Using Sustainability Reporting to Assess the Environmental Footprint of Copper Mining*. **Journal of Cleaner Production**, 40, pp 118–128.
9. Memary, R, Giurco, D, **Mudd, G M** & Mason, L, 2012, *Life Cycle Assessment: A Time-Series Analysis of Copper*. **Journal of Cleaner Production**, 33, pp 97-108.
10. Giurco, D, Prior, T, Mason, L, Mohr, S & **Mudd, G M**, 2012, *Life-of-Resource Sustainability Considerations for Mining*. **Australian Journal of Civil Engineering**, 10 (1), pp 47-56.
11. Weng, Z, **Mudd, G M**, Martin, T & Boyle, C A, 2012, *Pollutant Loads From Coal Mining in Australia: Discerning Trends From the National Pollutant Inventory (NPI)*. **Environmental Science & Policy**, 19-20 (1), pp 78-89.
12. Mohr, S, **Mudd, G M** & Giurco, D, 2012, *Lithium Resources and Production: Critical Assessment and Global Projections*. **Minerals**, 2 (1), pp 65-84 (doi:10.3390/min2010065).
13. **Mudd, G M**, 2012, *Key Trends in the Resource Sustainability of Platinum Group Elements*. **Ore Geology Reviews**, 46 (1), pp 106-117.
14. **Mudd, G M**, 2012, *Sustainability Reporting and the Platinum Group Metals: A Global Mining Industry Leader?* **Platinum Metals Review**, 56(1), pp 2-19.
15. Prior, T, Giurco, D, **Mudd, G M** & Behrisch, J, 2012, *Resource Depletion, Peak Minerals and the Implications for Sustainable Resource Management*. **Global Environmental Change**, 22 (3), pp 577-587.
16. Yellishetty, M, **Mudd, G M** & Ranjith, P G, 2011, *Environmental Life-Cycle Comparisons of Steel Production and Recycling: Sustainability Issues, Problems and Prospects*. **Environmental Science & Policy**, 14 (6), pp 650-663.
17. Mohr, S, Höök, M, **Mudd, G M** & Evans, G, 2011, *Long Term Projections of Australian Coal Production: Comparisons of Four Models*. **International Journal of Coal Geology**, 86 (4), pp 329-341.
18. **Mudd, G M**, 2011, *Book Review – Keith Johns, 'A Mirage in the Desert – The Discovery, Evaluation and Development of the Olympic Dam Ore Body at Roxby Downs, South Australia, 1975-88'*. **Historical Records of Australian Science**, 22 (1), pp 173-174.
19. Mason, L, Prior, T, **Mudd, G M** & Giurco, D, 2011, *Availability, Addiction and Alternatives: Three Criteria for Assessing the Impact of Peak Minerals on Society*. **Journal of Cleaner Production**, 19 (9-10), pp 958-966.
20. Qi, Y, Szendrak, D, Yuen, R T W, Hoadley, A F A & **Mudd, G M**, 2011, *Application of Sludge Dewatered Products to Soil and Its Effects on the Leaching Behaviour of Heavy Metals*. **Chemical Engineering Journal**, 166 (2), pp 586-595.
21. Yellishetty, M, **Mudd, G M** & Ranjith, P G, 2011, *The Steel Industry, Abiotic Resource Depletion and Life Cycle Assessment: A Real or Perceived Issue?*. **Journal of Cleaner Production**, 19 (1), pp 78-90.
22. Ferguson, B & **Mudd, G M**, 2011, *Water Quality, Water Management and the Ranger Uranium Project: Guidelines, Trends and Issues*. **Water Air & Soil Pollution**, 217 (1), pp 347-363.
23. **Mudd, G M**, 2010, *Global Trends and Environmental Issues in Nickel Mining: Sulfides versus Laterites*. **Ore Geology Reviews**, 38 (1-2), pp 9-26.
24. Boyle, C J, **Mudd, G M**, Mihelcic, J, et al, 2010, *Delivering Sustainable Infrastructure that Supports the Urban Built Environment*. **Environmental Science & Technology**, 44 (13), pp 4836–4840.

25. **Mudd, G M**, 2010, *The Environmental Sustainability of Mining in Australia: Key Mega-Trends and Looming Constraints*. **Resources Policy**, 35 (2), pp 98-115.
26. **Mudd, G M** & Patterson, J, 2010, *Continuing Pollution From the Rum Jungle U-Cu Project: A Critical Evaluation of Environmental Monitoring and Rehabilitation*. **Environmental Pollution**, 158 (5), pp 1252-1260.
27. Glaister, B J & **Mudd, G M**, 2010, *The Environmental Costs of Platinum-PGM Mining and Sustainability: Is the Glass Half-Full or Half-Empty ?* **Minerals Engineering**, 23 (5), pp 438-450.
28. **Mudd, G M** & Diesendorf, M, 2009, *Response to Comments on "Sustainability of Uranium Mining: Towards Quantifying Resources and Eco-Efficiency"*. **Environmental Science & Technology**, 43 (10), pp 3969–3970.
29. Browne, D, Deletic, A, **Mudd, G M** & Fletcher, T D, 2008, *A New Saturated/Unsaturated Model for Stormwater Infiltration Systems*. **Hydrological Processes**, 22 (25), pp 4838-4849.
30. **Mudd, G M**, 2008, *Comment on "Radium Hill: Bindi to Boom Town", by Kevin R. Kakoschke , Journal of Australasian Mining History, vol. 5, September 2007, pp. 135-149*. **Journal of Australasian Mining History**, 6, pp 176-181.
31. **Mudd, G M**, 2008, *Radon Sources and Impacts: A Review of Mining and Non-Mining Issues*. **Reviews in Environmental Science & Biotechnology**, 7 (4), pp 325-353.
32. **Mudd, G M**, 2008, *Sustainability Reporting and Water Resources: A Preliminary Assessment of Embodied Water and Sustainable Mining*. **Mine Water & Environment**, 27 (3), pp 136-144.
33. **Mudd, G M** & Diesendorf, M, 2008, *Sustainability of Uranium Mining: Towards Quantifying Resources and Eco-Efficiency*. **Environmental Science and Technology**, 42 (7), pp 2624-2630.
34. **Mudd, G M**, 2008, *Radon Releases From Australian Uranium Mining and Milling Projects: Assessing the UNSCEAR Approach*. **Journal of Environmental Radioactivity**, 99 (2), pp 288-315.
35. **Mudd, G M**, 2007, *Global Trends in Gold Mining: Towards Quantifying Environmental and Resource Sustainability ?* **Resources Policy**, 32 (1-2), pp 42-56.
36. **Mudd, G M**, 2007, *Gold Mining in Australia: Linking Historical Trends and Environmental and Resource Sustainability*. **Environmental Science & Policy**, 10 (7-8), pp 629-644.
37. **Mudd, G M**, 2007, *An Analysis of Historic Production Trends in Australian Base Metal Mining*. **Ore Geology Reviews**, 32 1-2), pp 227-261.
38. **Mudd, G M**, 2007, *An Assessment of the Sustainability of the Mining Industry in Australia*. **Australian Journal of Multi-Disciplinary Engineering**, 5 (1), pp 1-12.
39. **Mudd, G M**, Chakrabarti, S & J Kodikara, 2007, *Evaluation of Engineering Properties for the Use of Leached Brown Coal Ash in Soil Covers*. **Journal of Hazardous Materials**, 139 (3), pp 409-412.
40. Falk, J, Green, J & **Mudd, G M**, 2006, *Australia, Uranium and Nuclear Power*. **International Journal of Environmental Studies**, 63 (6), pp 845-857.
41. **Mudd, G M**, 2005, *A Detailed Analysis of Radon Flux Studies at Australian Uranium Projects*. **Radiation Protection in Australia**, December, 22 (3), pp 99-119.
42. **Mudd, G M**, 2005, *The Legacy of Early Uranium Efforts in Australia 1906 to 1945: From Radium Hill to the Atomic Bomb and Today*. **Historical Records of Australian Science**, 16 (2), pp 169-198.
43. **Mudd, G M**, T R Weaver & J Kodikara, 2004, *Geochemistry of Aged Brown Coal Ash*. **ASCE Journal of Environmental Engineering**, 130 (12), December, pp 1514-1526.
44. **Mudd, G M**, 2001, *Critical Review of Acidic In-Situ Leach Uranium Mining: 2 Soviet Block and Asia*. *Environmental Geology*, December 2001, 41 (3-4), pp 404-416.
45. **Mudd, G M**, 2001, *Critical Review of Acidic In-Situ Leach Uranium Mining: 1 USA and Australia*. **Environmental Geology**, December 2001, 41 (3-4), pp 390-403.
46. **Mudd, G M** & J Kodikara, 2000, *Field Studies of the Leachability of Aged Brown Coal Ash*. **Journal of Hazardous Materials**, 76 (2-3), pp 159-192.
47. **Mudd, G M**, 2000, *Mound Springs of the Great Artesian Basin in South Australia: A Case Study From Olympic Dam*. **Environmental Geology**, 39 (5), pp 463-476.

Publications – Journal Papers (under review)

Mudd, G M, Weng, Z, Memary, R, Northey, S A, Mohr, S, Giurco, D, & Mason, L, 2012, *Future Greenhouse Gas Emissions from Copper Mining: A Life Cycle Impact Assessment of Potential Clean Energy Scenarios*. **International Journal of Life Cycle Assessment**, Under Review.

Mudd, G M, Giurco, D, Memary, R, Mason, L & Prior, T, 2012, *Commodity Futures: Life-of-Resource Strategies for Copper and Gold*. **Minerals Engineering**, Under Review.

Mudd, G M, 2012, *Paste and Thickened Tailings – Friend Against Acid and Metalliferous Drainage?*. **IMM Transactions Section A – Applied Earth Science**, Under Review.

Publications – Major Research Reports and Handbooks

1. **Mudd, G M**, Weng, Z, Memary, R, Northey, S A, Giurco, D, Mohr, S & Mason, L, 2012, *Future Greenhouse Gas Emissions from Copper Mining: Assessing Clean Energy Scenarios*. Prepared for CSIRO Minerals Down

Under Flagship – Mineral Futures Collaboration Cluster, by the Department of Civil Engineering (Monash University) and Institute for Sustainable Futures (University of Technology Sydney), October 2012.

2. Mohr, S H, **Mudd, G M**, Mason, L, Giurco, D & Prior, T, 2012, *Coal: Production Trends, Sustainability Issues and Future Prospects*. Prepared for CSIRO Minerals Down Under Flagship – Mineral Futures Collaboration Cluster, by the Department of Civil Engineering (Monash University) and Institute for Sustainable Futures (University of Technology Sydney), October 2012.
3. Yellishetty, M, **Mudd, G M**, Mason, L, Giurco, D, Prior, T, & Mohr, S H, 2012, *A Critical Assessment of Australian and Global Iron Ore Resources: Production Trends, Sustainability Issues and Future Prospects*. Prepared for CSIRO Minerals Down Under Flagship – Mineral Futures Collaboration Cluster, by the Department of Civil Engineering (Monash University) and Institute for Sustainable Futures (University of Technology Sydney), October 2012.
4. **Mudd, G M**, Giurco, D, Mason, L, Prior, T, Mohr, S H & Yellishetty, M, 2012, *The Global Context of Gold Mining in Australia: A Peak Minerals Case Study*. Prepared for CSIRO Minerals Down Under Flagship – Mineral Futures Collaboration Cluster, by the Department of Civil Engineering (Monash University) and Institute for Sustainable Futures (University of Technology Sydney), October 2012.
5. Memary, R, **Mudd, G M**, Mohr, S H, Mason, L, Prior, T, Giurco, D & Weng, Z, 2012, *Resources and Technology: Future Scenarios for Copper in Australia*. Prepared for CSIRO Minerals Down Under Flagship – Mineral Futures Collaboration Cluster, by the Department of Civil Engineering (Monash University) and Institute for Sustainable Futures (University of Technology Sydney), October 2012.
6. van der Voet, E, Salminen, R, Eckelman, M, Norgate, T, **Mudd, G M**, Hischier, R, Spijker, J, Vijver, M, Selinus, O, Posthuma, L, de Zwart, D, van de Meent, D, Reuter, M, Tikana, L, Valdivia, S, Wäger, P, Hauschild, M & de Koning, A, 2012, *Environmental Challenges of Anthropogenic Metals Flows and Cycles*. Working Group Metals, UNEP International Resources Panel, September 2012.
7. **Mudd, G M**, Weng, Z & Codner, G P, 2012, *Monash Environmental Engineering Curriculum Review (2012)*. Prepared for the Faculty of Engineering, Monash University, Clayton, VIC, June 2012.
8. Mohr, S H, **Mudd, G M** & Giurco, D, 2012, *Lithium: A Peak Minerals Case Study*. Prepared for CSIRO Minerals Down Under Flagship – Mineral Futures Collaboration Cluster, by the Department of Civil Engineering (Monash University) and Institute for Sustainable Futures (University of Technology Sydney), June 2012.
9. Graedel, T E, Barr, R, Cordier, D, Enriquez, M, Hagelüken, C, Hammond, N Q, Kesler, S, **Mudd, G M**, Nassar, N, Peacey, J, Reck, B K, Robb, L, Skinner, B J, Turnbull, I, Ventura Santos, R, Wall, F & Wittmer, D, 2011, *Estimating Long-Run Geological Stocks of Metals*. Working Group on Geological Stocks of Metals, UNEP International Resources Panel, April 2011, 32 p.
10. **Mudd, G M**, 2010, *The Olympic Dam Mega-Expansion Without Uranium Recovery*. Peer-Reviewed Report for SA Greens MLC Mark Parnell and WA Greens Senator Scott Ludlam, Adelaide, SA, December 2010.
11. Mohr, S H, **Mudd, G M** & Giurco, D, 2010, *Lithium Resources: A Critical Global Assessment*. Prepared for CSIRO Minerals Down Under Flagship – Mineral Futures Collaboration Cluster, by the Department of Civil Engineering (Monash University) and Institute for Sustainable Futures (University of Technology Sydney), October 2010, 107 p.
12. Giurco, D, Prior, T, **Mudd, G M**, Mason, L & Behirsch, J, 2010, *Peak Minerals in Australia: A Review of Changing Impacts and Benefits*. Prepared for CSIRO Minerals Down Under Flagship – Mineral Futures Collaboration Cluster, by the Institute for Sustainable Futures (University of Technology, Sydney) and Department of Civil Engineering (Monash University), March 2010, 109 p.
13. *Evaluating Performance: Monitoring and Auditing Handbook*. Leading Practice Sustainable Development Program, Australian Department of Industry, Tourism & Resources and Minerals Council of Australia, October 2009, 142 p – ***Contributing Author***.
14. **Mudd, G M**, 2009, *Critical Review of Major Components of the 2009 Olympic Dam Expansion EIS*. Report for Australian Conservation Foundation, July 2009, 15 p.
15. **Mudd, G M**, 2009, *Prediction of Greenhouse Gas Emissions for the Olympic Dam Mega-Expansion*. Department of Civil Engineering, Monash University, April 2009, 13 p.
16. **Mudd, G M**, 2009, *The Sustainability of Mining in Australia - Key Production Trends and Their Environmental Implications for the Future*. Department of Civil Engineering, Monash University and Mineral Policy Institute, Melbourne, VIC, Research Report 5, October 2007 / Revised April 2009, 277 p.
17. **Mudd, G M**, 2009, *Ranger Tailings Dam Lift to RL54m: Conceptual Modelling of Potential Seepage Rates and Associated Environmental Aspects*. Report for Gundjeihmi Aboriginal Corporation, January 2009, 26 p.
18. *Risk Assessment and Management Handbook*. Leading Practice Sustainable Development Program, Australian Department of Industry, Tourism & Resources and Minerals Council of Australia, May 2008, 85 p – ***Contributing Author***.
19. Jolly, I, Rassam, D, Gilfedder, M, Stenson, M, Pickett, T, Barr, A, **Mudd, G M**, Silburn, M, Werner, A, McMahon, G, Johansen, C, Reid, M, Cheng, X, Christy, B, Weeks, A & Littleboy, M, 2008, *Review of Groundwater-Surface Water Interaction Modelling Approaches and Their Suitability for Australian Conditions*. Research Report, eWater CRC, Canberra, ACT.

20. *Tailings Management Handbook*. Leading Practice Sustainable Development Program, Australian Department of Industry, Tourism & Resources and Minerals Council of Australia, February 2007, 78 p – ***Contributing Author***.
21. *Managing Acid and Metalliferous Drainage Handbook*. Leading Practice Sustainable Development Program, Australian Department of Industry, Tourism & Resources and Minerals Council of Australia, February 2007, 96 p – ***Contributing Author***.
22. **Mudd, G M** & Smith, H D, 2006, *Comments on EIA Report – Proposed Kayelekera Uranium Project*. Report for Mineral Policy Institute, November 2006, 21 p.
23. **Mudd, G M**, 2004, *Review of the Kainantu Gold Project Environmental Plan*. Report for Mineral Policy Institute, February 2004, 8 p.
24. **Mudd, G M**, 2001, *Review of Water Management at Jabiluka: Environmental Issues and Recommendations*. Report for Gundjeihmi Aboriginal Corporation, December 2001, 31 p.
25. **Mudd, G M**, 1999, *A Review of Australia's Uranium Mining and the Proposed Jabiluka Uranium Mine: A Scientific Case for Placing Kakadu as WORLD HERITAGE IN DANGER*. Technical Submission by the Anti-Uranium Collective of Friends of the Earth (Fitzroy) to the World Heritage Committee, May 1999, 88 p.
26. **Mudd, G M**, 1998, *An Environmental Critique of In Situ Leach Mining: The Case Against Uranium Solution Mining*. Research Report for Friends of the Earth (Fitzroy) with The Australian Conservation Foundation, July 1998, 154 p.

Publications – Conference Papers (peer reviewed)

1. **Mudd, G M**, Weng, Z, Northey, S A, Jowitt, S M, Memary, R, Mohr, S, Giurco, D & Mason, L, 2013, *A Projection of Future Energy and Greenhouse Gas Emissions Intensity From Copper Mining*. Proc. "World Mining Congress 2013", Montreal, Canada, August 2013, ***Keynote Paper and Presentation***, Accepted.
2. **Mudd, G M**, 2013, *A Comprehensive Assessment of Existing and Future Energy and Greenhouse Gas Emissions Intensity From Uranium Mining*. Proc. "World Mining Congress 2013", Montreal, Canada, August 2013, Accepted.
3. Memary, R, Giurco, D, Prior, T, Mason, L, **Mudd, G M** & Peterseim, J, 2011, *Clean Energy and Mining – Future Synergies*. Proc. "2nd International Future Mining Conference 2011", Australasian Institute of Mining and Metallurgy, Brisbane, QLD, November 2011, pp 217-226.
4. Browne, D, Deletic, A, Fletcher, T & **Mudd, G M**, 2011, *Modelling the Development and Consequences of Clogging for Stormwater Infiltration Trenches*. Proc "12th International Conference on Urban Drainage", Acqua Consultoria, Brazil.
5. **Mudd, G M**, Smith, H D, Kyle, G & Thompson, A, 2011, *In-Pit Tailings – World's Best Practice for Long-Term Management of Tailings*. Proc. "MetPlant 2011: Metallurgical Plant Design and Operating Strategies", Australasian Institute of Mining and Metallurgy, Perth, WA, August 2011, pp 391-404.
6. **Mudd, G M**, 2011, *Paste and Thickened Tailings: Friend Against Acid and Metalliferous Drainage?*. Proc. "14th International Seminar on Paste and Thickened Tailings", Australian Centre for Geomechanics, Perth, April 2011, ***Keynote Paper and Presentation***, pp 187-202.
7. **Mudd, G M**, 2010, *The "Limits to Growth" and 'Finite' Mineral Resources: Re-visiting the Assumptions and Drinking From That Half-Capacity Glass*. Proc. "4th International Conference on Sustainability Engineering & Science", New Zealand Society for Sustainability Engineering & Science, Auckland, New Zealand, December 2010, 11 p.
8. Smith, T & **Mudd, G M**, 2010, *Shallow Groundwater Resources and Future Climate Change Impacts: A Comparison of the Ovens and Namoi Catchments, Eastern Australia*. Proc. "4th International Conference on Sustainability Engineering & Science", New Zealand Society for Sustainability Engineering & Science, Auckland, New Zealand, December 2010, 11 p.
9. Martin, T & **Mudd, G M**, 2010, *Investigation of the National Pollutant Inventory (NPI) as a Sustainability Tool*. Proc. "4th International Conference on Sustainability Engineering & Science", New Zealand Society for Sustainability Engineering & Science, Auckland, New Zealand, December 2010, 11 p.
10. Weng, Z, **Mudd, G M** & Boyle, C, 2010, *Projecting the Full Pollutant Cycle from Coal Utilization to 2200: Understanding the Global Environmental Implications*. Proc. "4th International Conference on Sustainability Engineering & Science", New Zealand Society for Sustainability Engineering & Science, Auckland, New Zealand, December 2010, 11 p.
11. Giurco, D, Prior, T, Mason, L & **Mudd, G M**, 2010, *Peak Minerals: Mapping Sustainability Issues at Local and National Scales*. Proc. "4th International Conference on Sustainability Engineering & Science", New Zealand Society for Sustainability Engineering & Science, Auckland, New Zealand, December 2010, 10 p.
12. **Mudd, G M**, 2010, *Platinum Group Metals: A Unique Case Study in the Sustainability of Mineral Resources*. Proc. "4th International Platinum Conference, Platinum in Transition 'Boom or Bust'", Southern African Institute of Mining and Metallurgy, Sun City, South Africa, October 2010, pp 113-120.
13. **Mudd, G M**, 2010, *The Ultimate Sustainability of Mining – Linking Key Mega-Trends with 21st Century Challenges*. Proc. "Sustainable Mining 2010 Conference", Australasian Institute of Mining and Metallurgy, Kalgoorlie, WA, August 2010, ***Keynote Paper and Presentation***, pp 351-373.

14. **Mudd, G M** & Diesendorf, M, 2010, *Uranium Mining, Nuclear Power and Sustainability – Rhetoric versus Reality*. Proc. "Sustainable Mining 2010 Conference", Australasian Institute of Mining and Metallurgy, Kalgoorlie, WA, August 2010, pp 315-340.
15. Prior, T, Giurco, D, **Mudd, G M**, Mason, L & Behrisch, J, 2010, *Resource Depletion, Peak Minerals and the Implications for Sustainable Resource Management*. Proc. "International Society for Ecological Economics (ISEE) 11th Biennial Conference", Oldenburg/Bremen, Germany, August 2010, 20 p.
16. Mason, L, Prior, T, **Mudd, G M** & Giurco, D, 2010, *Sustainable Mineral Resource Management: Peak Minerals in Australia*. Proc. "16th Annual International Sustainable Development Research Conference", Hong Kong, China, May 2010.
17. **Mudd, G M**, 2009, *Sustainability Reporting in Australia: An Important Part of the Solution*. Proc. "Solutions for a Sustainable Planet - SSEE International Conference 2009", Society for Sustainability and Environmental Engineering, Melbourne, Victoria, Australia, November 2009, 12 p.
18. Grima, V & **Mudd, G M**, 2009, *Calculating Greenhouse Gas Emissions in the Construction Industry*. Proc. "Solutions for a Sustainable Planet - SSEE International Conference 2009", Society for Sustainability and Environmental Engineering, Melbourne, Victoria, Australia, November 2009, 10 p.
19. **Mudd, G M**, 2009, *Sustainability Reporting and Mining: An Assessment of the State of Play for Environmental Indicators*. Proc. "4th International Conference on Sustainable Development Indicators in the Minerals Industry (SDIMI)", Australasian Institute of Mining and Metallurgy, Gold Coast, Queensland, July 2009.
20. Valero, A, Valero, A & **Mudd, G M**, 2009, *Exergy: A Useful Indicator for the Sustainability of Mineral Resources and Mining*. Proc. "4th International Conference on Sustainable Development Indicators in the Minerals Industry (SDIMI)", Australasian Institute of Mining and Metallurgy, Gold Coast, Queensland, July 2009.
21. Glaister, B J & **Mudd, G M**, 2009, *Platinum Mining and Sustainability: Understanding the Environmental Costs of Future Technologies*. Proc. "4th International Conference on Sustainable Development Indicators in the Minerals Industry (SDIMI)", Australasian Institute of Mining and Metallurgy, Gold Coast, Queensland, July 2009.
22. **Mudd, G M** & Ward, J D, 2008, *Will Sustainability Constraints Cause 'Peak Minerals' ?* Proc. "3rd International Conference on Sustainability Engineering and Science: Blueprints for Sustainable Infrastructure", Auckland, New Zealand, December 2008, 10 p.
23. Jessup, A & **Mudd, G M**, 2008, *Environmental Sustainability Metrics for Nickel Sulphide Versus Nickel Laterite*. Proc. "3rd International Conference on Sustainability Engineering and Science: Blueprints for Sustainable Infrastructure", Auckland, New Zealand, December 2008, 9 p.
24. Camenzuli, A & **Mudd, G M**, 2008, *Towards Comparative Environmental Sustainability Metrics for Geothermal Energy*. Proc. "3rd International Conference on Sustainability Engineering and Science: Blueprints for Sustainable Infrastructure", Auckland, New Zealand, December 2008, 10 p.
25. **Mudd, G M** & Diesendorf, M, 2007, *The Sustainability of Uranium Mining: The Growing Implications of Known Mineral Resources and Eco-Efficiency*. Proc. "SSEE 2007 International Conference on Engineering Sustainability", Perth, WA, November 2007, pp 351-359.
26. **Mudd, G M**, 2007, *Sustainability Reporting in the Gold Mining Industry: The Need for Continual Improvement*. Proc. "SSEE 2007 International Conference on Engineering Sustainability", Perth, WA, November 2007, pp 267-275.
27. **Mudd, G M**, 2007, *From Production to Sustainability Reporting – Towards Quantifying Sustainable Gold Mining*. Proc. "World Gold 2007 Conference", AusIMM, Cairns, October 2007, pp 117-127.
28. Browne, D, Deletic, A, **Mudd, G M** & Fletcher, T D, 2007, *A New Model for Stormwater Infiltration Systems*. Proc. "NOVATECH 2007 - 6th International Conference on Sustainable Techniques and Strategies in Urban Water Management", Lyon, France, June 2007, Vol. 2, pp 623-630.
29. **Mudd, G M**, 2007, *Resource Consumption Intensity and the Sustainability of Gold Mining*. Proc. "2nd Int Conf on Sustainability Engineering & Science: Talking & Walking Sustainability", Auckland, New Zealand, Feb 2007.
30. **Mudd, G M** & Diesendorf, M, 2007, *Sustainability Aspects of Uranium Mining: Towards Accurate Accounting ?* Proc. "2nd International Conference on Sustainability Engineering and Science: Talking and Walking Sustainability", Auckland, New Zealand, February 2007.
31. Valero, A, Valero, A, Martinez, A, **Mudd, G M**, 2006, *A Physical Way to Assess the Decrease of Mineral Capital Through Exergy: The Australian Case*. Proc. "9th Biennial Conf on the Int'l Society for Ecological Economics (ISEE): Ecological Sustainability and Human Well-Being", New Delhi, India, 15-18 December 2006.
32. **Mudd, G M**, Jelecic, S, Ginnivan, F & Reid, M, 2006, *Towards Quantifying Shallow Groundwater-Climate Relationships in Central and Northern Victoria*. Proc. "10th Murray-Darling Basin Groundwater Workshop", Canberra, September 2006, 5 p.
33. Thapa, K B, Clayton, S A, Hoadley, A F A & **Mudd, G M**, 2006, *Enhancing the MTE Dewatering of Sewage Sludge by Conditioning With Brown Coal*. Proc. "Chemeca 2006 - Knowledge and Innovation: Chemical Engineering Conference", Auckland, New Zealand, September 2006, 6 p

34. **Mudd, G M**, 2005, *An Assessment of the Sustainability of the Mining Industry in Australia*. Proc. "National Conf on Environmental Engineering: EES 2005 - Creating Sustainable Solutions", Sydney, Australia, July 2005, 6 p.
35. Wendelborn, A, **Mudd, G M**, Deletic, A & Dillon, P J, 2005, *Research on Metals in Stormwater for Aquifer Storage and Recovery in Alluvial Aquifers in Melbourne, Australia*. Proc. "ISMAR: International Symposium Management of Aquifer Recharge", Berlin, Germany, June 2005.
36. Chakrabarti, S, **Mudd, G M**, Kodikara, J, 2005, *Coupled Atmopsheric-Unsaturated Flow Modelling of Leached Ash Disposal in the Latrobe Valley, Australia*. Proc. "1st Int Conf on Engineering for Waste Treatment", Albi, France, May 2005, 8 p.
37. **Mudd, G M**, Chakrabarti, S & Kodikara, J, 2005, *Engineering Review of the Use of Leached Brown Coal Ash in Soil Covers*. Proc. "1st Int Conf on Engineering for Waste Treatment", Albi, France, May 2005, 6 p.
38. **Mudd, G M**, 2005, *Accounting for Increasing Mine Wastes in the Australian Mining Industry*. Proc. "1st Int Conf on Engineering for Waste Treatment", Albi, France, May 2005, 8 p.
39. **Mudd, G M**, Deletic, A, Fletcher, T D & Wendelborn, A, 2004, *A Review of Urban Groundwater in Melbourne: Considerations for WSUD*. Proc. "WSUD 2004: International Conference on Water Sensitive Urban Design", Adelaide, November 2004.
40. **Mudd, G M**, 2004, *Sustainable Mining: An Evaluation of Changing Ore Grades and Waste Volumes*. Proc. "International Conference on Sustainability Engineering & Science", Auckland, New Zealand, July 2004.
41. **Mudd, G M**, 2002, *Uranium Mill Tailings in the Pine Creek Geosyncline, Northern Australia: Past, Present and Future Hydrogeological Impacts*. Proc. "Uranium Mining & Hydrogeology III - 3RD International Conference", Freiberg, Germany, September 2002, pp 831-840.
42. **Mudd, G M**, 2002, *Environmental Hydrogeology of In Situ Leach Uranium Mining in Australia*. Proc. "Uranium Mining & Hydrogeology III - 3RD International Conference", Freiberg, Germany, September 2002, pp 49-58.
43. **Mudd, G M**, 2000, *Remediation of Uranium Mill Tailings Wastes in Australia: A Critical Review*. Proc. "2000 Contaminated Sites Remediation Conference", CSIRO Centre for Groundwater Studies, Melbourne, VIC, December 2000, Vol. 2, pp 777-784.
44. **Mudd, G M**, T R Weaver, J Kodikara & T McKinley, 1999, *Studies on the Attenuation of Sulphate in Latrobe Valley Groundwaters*. Proc. "Contaminated Sites Remediation Conference", CSIRO Centre for Groundwater Studies, Perth, WA, March 1999, pp 399-405.
45. **Mudd, G M** & J Kodikara, 1998, *Coal Ash Leachability: Detailed Field Studies*. Proc. "Australian Institute of Energy (AIE) – 8th Australian Coal Science Conference", Sydney, NSW, December 1998, pp 357-362.
46. **Mudd, G M**, 1998, *The Long Term Sustainability of Mound Springs in South Australia: Implications For Olympic Dam*. Proc. "Uranium Mining & Hydrogeology II Conference", Freiberg, Germany, September 1998, pp 575-584.
47. **Mudd, G M**, J Kodikara & T McKinley, 1998, *Groundwater Chemistry of the Latrobe Valley Influenced by Coal Ash Disposal - 2: Preliminary Kinetic Modelling*. Proc. "Groundwater: Sustainable Solutions", International Association of Hydrogeologists (IAH) Conference, Melbourne, VIC, February 1998, pp 521-526.
48. **Mudd, G M**, T R Weaver, J Kodikara & T McKinley, 1998, *Groundwater Chemistry of the Latrobe Valley Influenced by Coal Ash Disposal - 1: Dissimilatory Sulphate Reduction and Acid Buffering*. Proc. "Groundwater: Sustainable Solutions", International Association of Hydrogeologists (IAH) Conference, Melbourne, VIC, February 1998, pp 515-520.
49. **Mudd, G M** & J Kodikara, 1997, Modelling Coal Ash Leaching. Proc. "9th International Conference of the International Association for Computer Methods and Advances in Geomechanics (IACMAG)", Wuhan, China, November 1997, pp 1237-1242.
50. **Mudd, G M**, J Kodikara & T McKinley, 1996, *Assessing the Environmental Performance of Coal Ash Disposal*. Proc. "Australian Institute of Energy (AIE) – 7th Australian Coal Science Conference", Churchill, VIC, December 1996, pp 363-370.

Publications – Conference Papers & Presentations (not peer reviewed)

1. Jowitt, S M, **Mudd, G M** & Weng, Z 2013, *Global Cu Resources: Changing Trends and Endowments*. Pres. "26th Annual Winter Meeting of the MDSG", Leicester, UK, January 2013.
2. **Mudd, G M**, 2012, *Environmental Impacts of Coal and Coal Seam Gas: Groundwater and Surface Water Issues*. Invited Keynote Pres. "Beyond Coal and Coal Seam Gas Community Forum", Mackay, Queensland, Australia, July 2012.
3. **Mudd, G M**, Lane, R, Gumley, W & Impey, M, 2012, *Inter-Jurisdictional Challenges for EIA in Australia*. Pres. "IAG Annual Conference", Institute of Australian Geographers (IAG), Sydney, NSW, Australia, July 2012.
4. Northey, S, Haque, N, Norgate, T & **Mudd, G M**, 2012, *Role of Life Cycle Assessment for Improvement of Industrial Processes*. Pres. "CIPS2012 – CSIRO Intelligent Processing 2012", CSIRO, Melbourne, Victoria, Australia, May 2012.
5. **Mudd, G M**, 2012, *Coal Seam Gas, Fracking Chemicals and Groundwater*. Invited Pres. "HazMat 2012", Fire Protection Association of Australia (FPAA), Melbourne, Victoria, Australia, May 2012.

6. **Mudd, G M**, 2012, *What the Frack? Coal Seam Gas, Fracking and Groundwater*. Invited Pres. "DCQ-RAPAD Coal Seam Gas Community", Desert Channels Queensland (DCQ) and Remote Area Planning & Development Board (RAPAD), Barcaldine / Longreach, Queensland, Australia, April 2012.
7. **Mudd, G M**, Weng, Z & Codner, G, 2011, *Environmental Engineering at Monash University: History, Status and Sustainability in Engineering Education*. Proc. "Escaping Silos – SSEE International Conference 2011", Society for Sustainability and Environmental Engineering, Brisbane, Queensland, Australia, October 2011.
8. **Mudd, G M**, 2011, *The Lake Eyre Basin and Mining Issues: Current Status and Future Issues*. Invited Pres. "lake Eyre Basin Aboriginal Forum", Tibooburra, New South Wales, Australia, September 2011.
9. **Mudd, G M**, 2011, *Predicting the Future Sustainability of the Uranium Industry: Is There an Inevitable Nexus Between Ore Grade, Production and Recovery ?* Proc. "Australia's Uranium Conference 2011", AusIMM, Fremantle, June 2011.
10. **Mudd, G M**, 2010, *Questioning the Sustainability of Mining: The Hard Sustainability Challenges Remain*. Invited Pres. "Annual Sustainable Minerals Institute Post-graduate Research Conference", Brisbane, QLD, December 2010.
11. **Mudd, G M**, Giurco, D, & Prior, T, 2010, *Future Mine Site Feasibility and Sustainability: Peak Minerals*. Invited Pres. "2010 Mine Site Feasibility Conference", Perth, WA, June 2010.
12. **Mudd, G M**, 2010, *Nickel Sulfide Versus Laterite: The Hard Sustainability Challenge Remains*. Invited Pres. "2nd Euro Nickel Conference", Informa Pty Ltd, London, UK, March 2010.
13. Giurco, D, **Mudd, G M** & Prior, T, 2010, *Minerals Industry Strategies for Adapting to Climate Change*. Invited Pres. "2010 EcoForum Conference", Sydney, NSW, February 2010.
14. **Mudd, G M** & Glaister, B J, 2009, *Energy Consumption and Greenhouse Emissions Efficiency in Copper Mining: Forecasting Future Trends From Historical Data*. Proc. "Solutions for a Sustainable Planet - SSEE International Conference 2009", Society for Sustainability and Environmental Engineering, Melbourne, Victoria, Australia, November 2009.
15. **Mudd, G M**, 2009, *Mega-Trends and Environmental Constraints Facing 21st Century Mining*. Invited Virtual Pres. at "Young Earth Scientists Int Congress", Young Earth Scientists Network, Beijing, China, October 2009.
16. **Mudd, G M**, 2009, *Historical Trends in Base Metal Mining: Backcasting to Understand the Sustainability of Mining*. Proc. "48th Annual Conference of Metallurgists", Canadian Metallurgical Society, Sudbury, Canada, August 2009, pp 273-284.
17. **Mudd, G M**, 2009, *Nickel Sulfide Versus Laterite: The Hard Sustainability Challenge Remains*. Proc. "48th Annual Conference of Metallurgists", Canadian Metallurgical Society, Sudbury, Canada, August 2009, pp 23-32.
18. **Mudd, G M** & Glaister, B J, 2009, *The Environmental Costs of Platinum-PGM Mining: An Excellent Case Study in Sustainable Mining*. Proc. "48th Annual Conference of Metallurgists", Canadian Metallurgical Society, Sudbury, Canada, August 2009, pp 199-212.
19. **Mudd, G M**, 2008, *Mining, Water, Energy & Sustainability: A Fun Peak at Ongoing Research*. Invited Pres at "PECC Honolulu Water Resources Seminar", Pacific Economic Co-operation Council, Honolulu, Hawaii, Dec 2008.
20. Jolly, I, Rassam, D, Gilfedder, M, Stenson, M, Pickett, T, Turner, Barr, A, **Mudd, G M**, Silburn, M, Werner, A, McMahon, G, Johansen, C, Reid, M, Cheng, X, Christy, B, Weeks, A & Littleboy, M, 2008, *Predicting the Interactions Between Rivers and Groundwater Pumping*. Proc. "HydroPredict2008 - International Conference", Prague, Czech Republic, September 2008, pp 171-174.
21. **Mudd, G M**, 2008, *Can Uranium Mining Ever Be Considered 'Low' Environmental Impact ? Research, Case Studies & Policy - An NGO Perspective*. Invited Pres at "UMREG08 Meeting: Uranium Mine Remediation in Times of Revival of Production", Uranium Mine Remediation Exchange Group (UMREG), International Atomic Energy Agency and others, Freiberg, Germany, September 2008.
22. **Mudd, G M** & Patterson, J, 2008, *The Rum Jungle U-Cu Project: A Critical Evaluation of Environmental Monitoring and Rehabilitation Success*. Proc. "Uranium Mining & Hydrogeology – 5th International Conference", Freiberg, Germany, Springer, September 2008, pp 317-327.
23. Kabir, M, **Mudd, G M** & Ladson, A R, 2008, *Groundwater-Climate Relationships, Ranger Uranium Mine, Australia: 3. Predicting climate change impacts*. Proc. "Uranium Mining & Hydrogeology – 5th International Conference", Freiberg, Germany, Springer, September 2008, pp 383-392.
24. Kabir, M, **Mudd, G M** & Ladson, A R, 2008, *Groundwater-Climate Relationships, Ranger Uranium Mine, Australia: 2. Validation of unsaturated flow modelling*. Proc. "Uranium Mining & Hydrogeology – 5th International Conference", Freiberg, Germany, Springer, September 2008, pp 375-382.
25. Kabir, M, Hamza, K, **Mudd, G M** & Ladson, A R, 2008, *Groundwater-Climate Relationships, Ranger Uranium Mine, Australia: 1. Time series statistical analyses*. Proc. "Uranium Mining & Hydrogeology – 5th International Conference", Freiberg, Germany, Springer, September 2008, pp 365-374.

26. **Mudd, G M**, 2008, *Rethinking the Concept of Finite Mineral Resources: Understanding the Future Sustainability Constraints of 'Peak Minerals'*. Pres at "Institute of Aust Geographers Annual Conf", Hobart, July 2008.
27. **Mudd, G M**, 2008, *Mining, Water Resources and Sustainability in the Tropics: Some Ongoing Research Ideas #2*. Invited Pres at "PECC Noumea Water Resources Seminar", Pacific Economic Co-operation Council, Noumea, New Caledonia, May 2008.
28. **Mudd, G M**, 2008, *Mining, Water Resources and Sustainability in the Tropics: Some Ongoing Research Ideas #1*. Invited Pres "PECC Noumea Water Resources Seminar", Pacific Economic Co-operation Council, Noumea, New Caledonia, May 2008.
29. **Mudd, G M**, 2007, *Groundwater, Mining and Sustainability in the Tropics: Some Research Case Studies*. Invited Pres at "PECC Bora Bora Water Resources Seminar", Pacific Economic Co-operation Council, Bora Bora, French Polynesia, November 2007
30. **Mudd, G M**, 2007, *The Great Artesian Basin: Groundwater Resources and Regulatory Framework*. Invited Pres at "Water and Mining Conference 2007", Adelaide, SA, November 2007.
31. **Mudd, G M**, 2007, *Towards Quantifying the Sustainability of Mining in Australia: Linking Production to Sustainability Reporting and Beyond*. Proc. "Sustainable Development Conference - A Climate of Change", Minerals Council of Australia, Cairns, October 2007.
32. Kabir, M, **Mudd, G M** & Ladson, A R, 2007, *Understanding the Inconsistencies Between Two Different Sources of Morton's AAET Data for Ranger Uranium Mine Site, Northern Territory, Australia*. Proc. "21st Victorian Universities Earth & Environmental Sciences Conf", Geological Society of Australia, Abstracts No. 86, September 2007, Bundoora, Abstract Paper.
33. **Mudd, G M**, 2007, *Sustainability and Mine Waste Management – A Snapshot of Mining Waste Issues*. Invited Pres at "Waste Management and Infrastructure Conf", IIR Conferences, Melbourne, September 2007, 10 p.
34. **Mudd, G M**, 2007, *Water & Mining in Australia: Towards an Improved Future ?* Invited Pres at "Connect '07: Conservation Council of South Australia Annual Environment Conference", May 2007, Adelaide, SA.
35. **Mudd, G M**, Kyle, G & Smith, H D, 2007, *Mirarr Perspectives on Mining and Rehabilitation of the Ranger Project Area*. Proc. "Australia's Uranium Conference 2007", AusIMM, Darwin, May 2007.
36. Dean, A J & **Mudd, G M**, 2006, *Climate Change and Urban Groundwater Recharge*. Proc. "2nd Australasian Hydrogeology Research Conf", Adelaide, December 2006, Abstract.
37. Kabir, M, **Mudd, G M**, Ladson, A R, 2006, *The Application of Time Series Techniques to Groundwater Level and Climate Relationships*. Proc. "2nd Australasian Hydrogeology Research Conf", Adelaide, December 2006, Abstract.
38. Kabir, M, **Mudd, G M** & Ladson, A R, 2006, *Understanding the Groundwater Recharge Process Near the Ranger Mine in the Northern Territory*. Proc. "2nd Australasian Hydrogeology Research Conf", Adelaide, December 2006, Abstract.
39. **Mudd, G M**, 2006, *Uranium Mining: Is It Environmentally Sustainable?* Invited Pres at "UNSW Institute of Environmental Studies Forum on Nuclear Power", Sydney, October 2006.
40. **Mudd, G M**, 2005, *An Environmental History of Uranium Mining in Australia: A Scientific Review*. Invited Pres at "Australian Uranium Conference 2005", Fremantle, October 2005, 18 p.
41. **Mudd, G M**, 2005, *From Radium to Uranium: The Importance of Australia's Radium Industry to the Cold War Uranium Effort*. Pres. "Annual Conference of the Australian Mining History Association", Bendigo, July 2005.
42. Kabir, M, **Mudd, G M**, 2004, *Modelling Long-Term Groundwater Rebound and Recharge at Ranger Uranium Mine, Kakadu National Park*. Proc. "Inaugural Australasian Hydrogeology Research Conference", Melbourne, December 2004, Poster Abstract.
43. Wendelborn, A, **Mudd, G M**, Deletic, 2004, *Water Quality Issues For Injection Aquifer Recharge and Recovery in Melbourne*. Proc. "Inaugural Australasian Hydrogeology Research Conference", Melbourne, December 2004, Poster Abstract.
44. **Mudd, G M**, 2004, *One Australian Perspective on Sustainable Mining: Declining Ore Grades and Increasing Waste Volumes*. Proc. "Tailings & Mine Waste '04", Vail, Colorado, USA, October 2004, Taylor & Francis, pp 359-369.
45. **Mudd, G M**, 2004, A Compendium of Radon Data for the Rehabilitation of Australian Uranium Projects. Proc. "Tailings & Mine Waste '04", Vail, Colorado, USA, October 2004, Taylor & Francis, pp 247-260.
46. **Mudd, G M**, 2004, *Environmental Reporting and Sustainable Mining: Encouraging Mining Companies to Close the Data Gaps*. Oral Presentation at "Innovating Corporate Social Responsibility Conference", Monash Governance Research Unit, Caulfield, 14 May 2004.
47. **Mudd, G M**, 2002, *Uranium Mining in Australia: Environmental Impact, Radiation Releases and Rehabilitation*. Invited Pres at "SPEIR 3 – Symposium on Protection of the Environment From Ionisoing Radiation", Darwin, NT, July 2002, pp 179-189.
48. **Mudd, G M**, 2000, *Uranium Mill Tailings Wastes in Australia: Past, Present and Future Management*. Keynote Pres. "Conference of the Medical Association for the Prevention of War", Canberra, ACT, August 4-6, 2000, 16 p.

49. **Mudd, G M**, 2000, *Radioactive Waste Repositories: Environmental Review of Permanent Threats to Arid Groundwater Resources*. Proc. "People's Conference 2000 - Nuclear Waste Repository Proposals for South Australia", Adelaide, SA, March 4-5, 2000, 12 p.
50. **Mudd, G M**, 2000, *Acid In Situ Leach Uranium Mining: 2 Soviet Block and Asia*. Proc. "Tailings & Mine Waste '00 – 7th Int Conf", Fort Collins, CO, USA, January 23-26, 2000, pp 527-536.
51. **Mudd, G M**, 2000, *Acid In Situ Leach Uranium Mining: 1 USA and Australia*. Proc. "Tailings & Mine Waste '00 – 7th Int Conf", Fort Collins, CO, USA, January 23-26, 2000, pp 517-526.
52. **Mudd, G M**, 1998, *The Sustainability of Mound Springs In South Australia: Implications For Olympic Dam*. Proc. "Commission on Mineral & Thermal Waters Meeting - International Association of Hydrogeologists (IAH)", Ballarat, VIC, September 21-24, 1998, 14 p.