Some Comments on the Draft Report of the Thirlmere Lakes Inquiry

July 2012

"The local community’s concerns about the protection of Thirlmere Lakes have been ignored for too long. It is time that we established the real facts as the basis for making decisions about this important conservation area."

The Hon. Robyn Mary PARKER, Minister for the Environment, and Minister for Heritage. 25th October 2011.

Attachments:
3 and 4. ‘Impacts of Longwall Mining and Coal Seam Gas Extraction on Groundwater Regimes in the Sydney Basin; Parts 1 and 2’; S E Pells and P J N Pells, accepted for publication in Australian Geomechanics. Emailed to the secretariat Friday July 20 and to the Committee on July 12.

NOTE: Time constraints have precluded proof reading of this document.
**Summary**

- The draft Report and the minutes of the public meeting held on July 6th indicate that the Committee has concluded that Tahmoor Colliery has not had a significant impact on the Thirlmere Lakes. As discussed below, rainfall record comparisons, anecdotal evidence, hydrology and modelling collectively suggest that the lakes have anomalously dried during a relatively mild dry period and that the mine has been a significant factor in this evidently being a premature event. Were it not for the influence of the mine, the lakes might not yet be dry.

- Best practice environmental assessments judiciously apply the Precautionary Principle, for which the trigger conditions and consequential 'reverse onus of proof' requirement have been specified by the Chief Judge of the Land and Environment Court. The draft Report does not reflect the advice provided by the Precautionary Principle, which includes giving the benefit of the doubt to the environment.

- A comparison of the recent dry period from 1992 to 2007 with past rainfall records show it to be comparatively mild relative to the two dry periods that precipitated the drying of the lakes last century (Figs 1,3 and 4 within). That is, it would appear the lakes have dried prematurely. The draft Report does not make this comparison and does not note or comment upon the ranking of droughts made in the Pells Consulting report on the drying of the lakes. Given an indicative comparison is possible and of importance, this omission is puzzling. The Bureau of Meteorology’s use of deciles or the Standardised Precipitation Index could be used for ranking.

- The draft Report interchangeably uses, or conflates, the terms ‘dry period, drought dominated regime’ and ‘drought’. To avoid confusion, and any perception of an exaggeration of the recent drought, it would be helpful if the Report adopted a definition of drought consistent with that used by the Bureau of Meteorology. The Bureau of Meteorology uses deciles to assess drought; a widely used alternative is the Standardised Precipitation Index.

- There is anecdotal evidence that the lakes have dried more extensively than in past and are not filling as might be expected. Given the uncertainty and significance of the consequences, the Precautionary Principle requires that this possibility is accepted until proven otherwise.

- While the draft Report discusses subsidence impacts in some detail, it notes but does not further consider surface or near surface impacts that may arise in the absence of subsidence effects, as a consequence of depressurisation associated with mine dewatering. Given this is a physically real possibility and has been of concern for other inquiries and investigations in the Sydney Basin, this omission is puzzling. Again, the Precautionary Principle requires that this possibility is accepted until proven otherwise.

- The Committee evidently prefers the perspective of the Bald Hill Claystone advocated by Heritage Computing and Parsons-Brinckerhoff, as insulating the Hawkesbury Sandstone from depressurisation as a result of mine dewatering. The draft Report does not consider the evidence compiled by Pells and others that the Bald Hill Claystone is complex and has permeabilities overlapping that of the Hawkesbury Sandstone and other formations. Pells provides details in his Thirlmere Lakes report and in two manuscripts that have been accepted for publication in Australian Geomechanics (attached and emailed to the Committee).

- The draft Report notes reports of bore water loss and attributes the cause to geological faults without consideration the influence of mine dewatering.

- The draft Report notes but does not further consider evidence suggesting a vertical ground water gradient below Lake Couridjah. Elsewhere the Report highlights an increased horizontal flow to the east.

- The draft report notes Tahmoor Colliery piezometer records indicating depressurisation of the Bald Hill Claystone and Hawkesbury Sandstone. With suggestions of instrument unreliability,
the implications are not considered in the draft Report, other than to emphasize increased flow to the east. Given the uncertainty and significance of the consequences, the Precautionary Principle requires that the possibility of significant mine-related depressurization effects be accepted until proven otherwise.

- The draft Report does not reflect the substantial updates to the Pells study presented at the public forum held by Wollondilly Council on May 22. The Committee Chair also gave a presentation at that meeting. The update included a correction to survey data such that the lake levels and volumes determined by Pells and Gilbert and Associates (G&A) are essentially the same.

- The draft Report is dismissive of the modelling undertaken by Pells Consulting and G&A. The Committee observes that the modelling is challenged by limited data and the complexity of the system being modelled. Advice from practitioners suggests that this is not an unusual situation and provided sufficient caution is exercised, modelling may nonetheless be instructive. The modelling is used to explore possibilities and is not intended to be deterministic or predictive.

- The modelling undertaken by Pells Consulting and G&A is essentially the same. Both include climate change (implicitly, both natural and anthropogenic), hydrology and catchment parameters. The key difference is that G&A optimise their model to fit the recently observed lake levels, whereas the Pells modelling is optimised with respect to observations prior to 2000. The former shows historical levels generally lower than observed, while the latter shows post 2000 levels higher than those observed. The latter is more consistent with the emerging evidence. That is, the latter suggests a water balance anomaly and gradient changes consistent with evidence of a vertical groundwater gradient and coincident with the nearby passage of longwalls and dewatering at Tahmoor Colliery.

- A key parameter in fitting the models to the observations is the natural deep groundwater recharge parameter. The Pells model uses a modest value of 25 mm/year, based on an assessment of strata permeability. It would appear that G&A use a much higher value and that different values are used for each lake, ranging from 300 to 1000 mm/year for recharge from full lakes. G&A report their recharge parameters as kL/day; in converting to mm/year it’s not clear what the associated surface area values are. Nonetheless it would seem G&A use recharge parameters at least an order of magnitude greater than used by Pells. This is inconsistent with the assumption of restrictive subsurface vertical permeability.

- The draft Report pays little attention to the level of dewatering at Tahmoor Colliery, focusing its attention on the more reliable post 2009 records (the mine’s closest approach was between 1999 and 2002). The low resolution of Figure 8-13 renders it unreadable, but this NOW figure is available in other reports. It suggests dewatering of 2 to 8 or more ML/d from 2002 to 2009, consistent with anecdotal reports, and there are reports of dewatering at that level for some considerable time before 2002. Rather than dismiss the evidence and reports of substantial and sustained dewatering as unreliable, as the Committee evidently does, the Precautionary Principle requires that this is accepted until proven incorrect.

- De-watering at 4 ML/day is equivalent to 1460 ML/year, close to the 1770 ML summation of the full volumes of all the lakes. The draft Report observes that the recharge parameters reported by G&A suggest that in the absence of recharge (and presumably evaporation) the lakes would naturally drain from full in about 5 years. The parameters used by G&A appear to be unrealistically large, in which case drainage would take decades. Mine dewatering at 4 ML/day removes an equivalent amount of water from the surrounding strata in one year.

- Case law provides guidance on what is best practice with respect to avoiding concerns of bias. In essence, if a fair minded observer might reasonably apprehend that one or more the Inquiry members might not have brought an impartial and unprejudiced mind to the determination, then the Inquiry may be judged to be affected by bias.
# Table of Contents

Preliminary Comments  
Relevance and Application of the Precautionary Principle  
The Risk of A Reasonable Apprehension of Bias  
Reliability of Proponent Funded Environmental Assessments  
Identifying and Characterising the Recent Drought  
Omission of a Comparative Assessment of the Recent Drought  
The Use of Daily Rainfall Records  
The Extent of the Recent Drying of the Lakes  
Significant Water Removal at Tahmoor Colliery  
Corrections to Lake Level and Volume Observations Reported by Pells  
The Value of Modelling  
Ground Water Re-Direction as a Result of Water Removal at Tahmoor Colliery  
The Character of the Bald Hill Claystone According to Pells  
De-watering Impacts According to Heritage Computing and Parsons-Brinkerhoff  
Dating the Water  
Conclusion  
List of Recommendations  
References
Preliminary Comments

The Inquiry was prompted by community concern that the Thirlmere Lakes had dried under unusual circumstances, with the collective community knowledge extending back to before World War II. Part of the task of the Committee is then to assimilate the community’s knowledge and address its concerns.

The draft states that the Report has been tested in both the scientific and community domains. While the draft has notably commendable aspects for which the Committee is to be congratulated, at this stage its omissions and dismissals put it at risk of notably failing the community test. The Committee members who attended the public meeting of July 6 may have gained a sense of this possibility.

The draft Inquiry Report does not indicate how it has been tested in the scientific community.

It is regrettable that the Inquiry has not engaged more effectively with Dr Philip Pells.

The community was surprised when it learned that the otherwise unnamed consulting company Dr McLean works for was Parsons-Brinkerhoff. A fair minded person would have reasonable cause for concern on learning that a Committee member works for a consultancy for an industry that undertakes coal seam de-watering. As noted below, the NSW Planning Assessment Commission has expressed its concerns regarding the objectivity of industry consultants.

Relevance and Application of the Precautionary Principle

The Precautionary Principle should apply to the Inquiry as a well established principle of environmental law and best practice guideline for all environmental assessments and decisions. The Precautionary Principle has been included either specifically or by inference as part of Ecologically Sustainable Development (ESD) in many Australian environmental statutes. The Commonwealth Environment Protection and Biodiversity Conservation Act 1999 states the requirements for environmental impact assessments, which includes incorporating the promotion of ESD and the Precautionary Principle. The National Strategy for Ecological Sustainable Development (1992) adopts the Precautionary Principle as a “core element” of ESD as does the Inter-Governmental Agreement on the Environment (IGAE). The IGAE requires decisions to be guided by the Precautionary Principle.

In NSW, the principle is reflected or applied in over 47 laws. The Chief Judge of the NSW Land and Environment Court has stipulated the ‘trigger’ conditions for the application of the Precautionary Principle.[1] In short those conditions are:

(i) A threat of serious or irreversible environmental damage;
(ii) scientific uncertainty as to the environmental damage.

Once both pre-conditions are satisfied, the principle is triggered. The consequences are:

(i) The burden of proof shifts to the proponent who must now demonstrate that the threat either does not exist or is negligible.
(ii) Unless the proponent discharges the burden of proof the decision maker must assume that the threat is a reality rather than uncertain.
(iii) The preference is to prevent the damage rather than remediate it.
The Southern Coalfields Inquiry comments “Due to the extent of current knowledge gaps, a precautionary approach should be applied to mining which might unacceptably impact highly-significant natural features.” It goes on to state that “The approvals process should require a ‘reverse onus of proof’ from the mining company before any mining is permitted which might unacceptably impact highly-significant natural features.”

The NSW Planning Assessment Commission discusses in some detail the application of the Precautionary Principle in reviewing the BHP-B Bulli Seam Operations Project.[2] The discussion is in the context of the Upland Swamps which, like the lakes, are threatened by coal mining and anthropogenic climate change – as has been recognised by the NSW Scientific Committee.

Given the current knowledge gaps, the Precautionary Principle is applicable for the conduct and findings of the Thirlmere Lakes Inquiry. The consequential shift in the burden of proof would require that the Inquiry make the following assumptions until they can be shown to be incorrect:

(i) That community concerns that the lakes have dried prematurely and more extensively than in the past are correct.

(ii) That Tahmoor Colliery has removed water at 2 to 8 ML/day between 2002 and 2009 and may have removed up to 4 ML/day or more for some considerable time before 2002.

(iii) That depressurisation across the Bald Hill Claystone will occur as a consequence of coal mining activity, whether or not this stratum has been disrupted by subsidence. This is consistent with evidence the character of the Bald Hill Claystone layer is complex and variable from location to location, and has permeability characteristics that overlap with those of sandstone strata.

(iv) That modelling undertaken by Pells Consulting correctly suggests a post 2000 water balance anomaly that cannot be accounted for by climate change (natural and anthropogenic), natural hydrological and catchment processes and the use of water pumps at the surface.

(v) That while the onset of a significant dry period is the primary cause of the drying of the lakes, dewatering at the Tahmoor Colliery is a significant contributing factor.

As discussed below, the recent dry period and drought appears to be mild in comparison to those that led to the lakes drying last century. That is, the evidence suggests the lakes have dried prematurely.

**Recommendation 1:** The Report adopt best practice and heed the advice of the Precautionary Principle. Where appropriate the Report should indicate where the Precautionary Principle has been applied.

**The Risk of A Reasonable Apprehension of Bias**

Clearly it is in the public interest that independent inquiries are undertaken, and seen to be undertaken, in accordance with best practice. Case law provides guidance on what is best practice with respect to avoiding concerns of bias. In essence, if a fair minded observer might reasonably apprehend that one or more the Inquiry members might not have brought an impartial and unprejudiced mind to the determination, then the Inquiry may be judged to be affected by bias.
Although it is not mentioned on the Inquiry Web site, was not mentioned in the Minister’s press release and is not mentioned in the draft report, Dr Wendy Mclean is a principal hydrogeologist with Parsons-Brinckerhoff (PB). PB is a company that provides environmental impact assessment services to coal and coal seam gas companies operating in NSW, including the Sydney Basin, such as Xstrata and AGL. Clearly there is cause for concern of a conflict of interest.

As it stands, puzzling aspects of the draft Report may give sufficient cause for concern that the Inquiry may reasonably be judged to be affected by bias.

Announcing the Inquiry in October 2011, the Minister’s press release for the Inquiry states that Dr McLean is “a senior hydrogeochemist with a major consulting firm (participating in a personal capacity).” As outlined below, in January 2012 Dr McLean signed off as an author for a Parsons-Brinckerhoff groundwater assessment undertaken on behalf of AGL for their Gloucester Gas Project. That assessment concludes that dewatering associated with CSG extraction will have not have any significant impact on surface or near surface waters, because of ‘insulation’ provided by intervening strata. Parsons-Brinckerhoff find likewise for AGL’s Camden Gas Project expansion proposal. Other experts find fault with the assumptions, analysis and conclusions made by Parsons-Brinckerhoff. At the very least, there is cause for doubt about the reliability of groundwater assessments made by Parsons-Brinckerhoff.

**Recommendation 2:** The Report should clearly state that Dr Mclean is an employee of Parsons-Brinckerhoff, a mining industry consultancy, and has undertaken work in that capacity during the course of the Inquiry that is related to the consideration of the impact of Tahmoor Colliery on the drying of Thirlmere Lakes.

### Reliability of Proponent Funded Environmental Assessments

There are long standing concerns and difficulties arising from environmental impact assessments provided by proponent selected and funded consultants, such as Parsons-Brinckerhoff, Heritage Computing and Gilbert and Associates. The problem is discussed in the NSW Planning Assessment Commission (PAC) report for the BHP-B Bulli Seam Operations project[2], where the PAC expresses its frustration in the following recommendation:

“15.3.4. Recommendation
The Panel recommends that the Department look at this issue with a view to determining whether independent selection and briefing of reviewers should be the norm, even if the cost were borne by the Proponent. As it currently stands the system appears to have little credibility.”

Of direct relevance to the Inquiry, the PAC is notably critical of the proponent’s ground water assessment, which includes work from Heritage Computing.

It is a concern then that the draft Inquiry Report does not comment on the potential for bias in proponent funded assessments. It is also a concern that the draft report does not note that the extensive and ongoing study of the Thirlmere lakes undertaken by Dr Philip Pells was self-funded and not undertaken on behalf of any organisation, group or individual.[3]
Identifying and Characterising the Recent Drought

Referring to cumulative deviation graphs in Figure 4-7, on page 105 the draft Report observes as follows; “The graphs show that there was a period of above average rainfall from 1989 to 1992, there was a decline from 1992 to 2007, which steepened in 2002, and since 2007 there has been an oscillation around the average rainfall. The steepening in 2002 could be described by the expression “the drought intensified”.”

In making this observation the draft report conflates the notion of drought dominated regime or dry period with that of drought. This is repeated with “This period of drought (1992 to 2007) is part of a recurring pattern of drought- and flood-dominated regimes in Eastern Australia.”

Gilbert and Associates likewise interchange the terms ‘drought/ and ‘dry period’. On page 22 of their submission on behalf of Xstrata they state; “Positive slopes are indicative of periods of high rainfall and negative slopes of dry or drought periods.” This comment then would suggest that positive slopes in cumulative anomaly graphs indicate a time of flood. On page 13 Gilbert and Associates identify a dry period from “1900 to 1946” (see Fig. 1 below) but they do not suggest this as a period of drought. That period includes the two widely recognised droughts that precipitated the drying of the lakes in the last century; the Federation drought (1895-1902)[4(a)] and the World War II drought (1937-1945)[4(b)].

The Bureau of Meteorology comments on the Federation Drought “By February 1902 concerns were expressed about Sydney’s water supply, and the New South Wales Government declared 26 February a day of “humiliation and prayer” for rain in that state.” Noting that the WWII drought didn’t end until 1947 in NSW, the BoM comments; “As the drought extended into 1945, large rivers virtually dried up. By December 1944 the Hunter had ceased to flow along most of its course; by January the Hawkesbury was dry at North Richmond.”

Interchanging ‘dry period’, ‘drought dominated regime’ and ‘drought’ without distinction gives cause for confusion and in effect exaggerates the recent drought. The BoM observes “Many of Australia’s worst droughts occur when one or two very dry years follow several years of generally below average rainfall”. [4(a)] The onset of a generally dry period from around 1992 would not be generally regarded as the start of the recent drought. The Millennium drought is generally regarded as being from 2001 to 2006.

The draft Report observation quoted above also incorrectly implies a drought steepening from 2002 to 2007, whereas the steepening referred to occurred from 2002-2003, corresponding to an El Niño period. Figure 2 shows recent El Niño and La Niña events with respect to the Southern Oscillation Index.[5] There was a particularly strong El Niño in 1997-98, associated with an unusually hot year that is often ‘cherry picked’ by climate change sceptics, and this was followed by a pro-longed La Niña period from 1998 to 2001. In being the opposite phase to El Niño, La Niña periods are associated with higher rainfall and lower temperatures. The cooling is relatively strongest across summer during the October to March period. More recently there was a prolonged ‘double’ La Niña from 2010 into 2012.
Figure 1. Cumulative Rainfall Anomaly for Thirlmere Lakes – Figure 3-6 from the Gilbert and Associates Submission to the Inquiry on behalf of Xstrata.

Figure 2. Bureau of Meteorology depiction of the Southern Oscillation Index and El Niño and La Nina events from 1994 to 2007. [5]
It would be very helpful if the report provided a definition of drought, and accordingly identified and characterised drought periods. The Bureau of Meteorology uses deciles to identify drought as a period of serious or severe rainfall deficiency[6]:

- Serious rainfall deficiency:- rainfall lies above the lowest five per cent of recorded rainfall but below the lowest ten per cent (decile 1 value) for the period in question,
- Severe rainfall deficiency:- rainfall is among the lowest five per cent for the period in question.

The Standardised Precipitation Index (SPI) is also used to identify and characterise periods of drought. A comparative assessment of the use of deciles and the use of the SPI has relatively recently been made with respect to drought in NSW, and shows the method used by the Bureau of Meteorology to be simple and effective.[7]

**Recommendation 4:** The Report adopts a recognised definition of drought and distinguishes the term ‘drought’ from ‘dry period’ and ‘drought dominated regime’. The Report should accordingly identify and distinguish dry periods and periods of drought.

**Omission of a Comparative Assessment of the Recent Drought**

The draft report makes no attempt to assess the recent drought and preceding dry period in a comparative historical context. On page 105 the draft notes a 1400 mm deficit over the 15 year dry period of 1992 to 2007. The rainfall records used for this summation presumably do not extend back far enough, but the draft report establishes a good correlation between Picton and other local area rainfall records. A comparative assessment would appear to be possible.

Residual mass or rainfall anomaly trends are represented in Figure 4-9 in the draft report (an overlay of multiple regional records), in Figure 3-6 in the Xstrata funded Gilbert and Associates submission (Fig. 1 above), in Figure 11 in the Xstrata funded Heritage Computing submission (Fig. 3 above), Figures 5.9 and 5.10 in the Pells report and Figure 2 in Progress Report Number 3 of the Appendix to the Pells report (Fig. 4 below). These representations indicate that the recent dry period was less severe than the dry periods of the Federation and World War II (WWII) droughts. This observation was agreed by climate scientists contacted for their opinion.

Pells further uses five year and three year intervals to rank drought periods and finds the 2002-6 Millennium drought period ranks 6th (Tables 2.1 and 2.2 pages 17 and 18 Pells Report). The Federation and WWII drought periods were the worst.

The draft Inquiry report does not address or consider this clearly important observation and its implications. The lakes appear to have dried prematurely relative to the previous causative droughts, the Federation and the WWII drought.
Figure 11. Residual mass plots showing long-term trends in climate indicators.

Figure 3. Cumulative Rain and Temperature Anomalies – Figure 11 from the Heritage Computing Submission to the Inquiry on behalf of Xstrata.

Figure 2: Calibration and drought analysis of rainfall records from 1858 to 2010.

Figure 4. Cumulative Rainfall Anomalies – Figure 2 in Progress Report Number 3 contained in the Appendix to the Report on the Water Levels of Thirlmere Lakes from Pell Consulting.
On pages 105 to 108 the draft Report rainfall patterns beyond the catchment area relevant to the Thirlmere Lakes are considered from an historical perspective, concluding with the following: “All the available evidence from the temporal rainfall data suggests that the pattern of drying identified for Thirlmere lakes over the last 100 years is entirely consistent with the pattern seen in other lakes and in the rainfall record. If the lakes dried out in the previous drought-dominated regimes they would be expected to be dry in the present regime.”

This conclusion in the report should be qualified, given the significant observation that the recent dry period does not appear to have been as severe as the two dry periods that led to the drying of the lakes twice last century.

It’s puzzling that the draft report only considers local rainfall trends from 1989 to the beginning of 2012. That is, in considering local data the report focuses on the recent dry period, which includes the Millennium drought, and does not consider that period in the longer term context. The report notes the good correlation across local rainfall records; an assessment of the recent drought in the longer term context is clearly possible.

The approach used by Pells to compare droughts is effectively similar to that used by the Bureau of Meteorology, which has recently been favourably evaluated against the Standardised Precipitation Index as a means of identifying and ranking droughts in NSW.[7]

**Recommendation 5:** The Report recognises in the executive summary and the main text that the lakes have dried during a comparatively mild drought period prematurely and have in effect dried prematurely. The Report should include a comparative assessment of the recent drought using the method employed by the Bureau of Meteorology or the Standardised Precipitation Index.

---

**The Use of Daily Rainfall Records**

The use of daily records is puzzling and unnecessarily highlights very short term variations that obscure more informative trends. Monthly or annual aggregations are clearer, more informative and used by others such as the Bureau of Meteorology.

**The Extent of the Recent Drying of the Lakes**

On page 33 the draft Report suggests that there is an open debate as to which lakes were dry and when. Pells however is confident that the recent lake drying is more extensive than in the past. He notes that 2011 is not the first time Lakes Werri Berri and Gandangarra have been dry and states there is clear evidence that these two lakes were dry sometime around 1944 as a result of the WWII drought. Pells suggests however that the present period is the only time that Lakes Nerrigorang and Couridjah are known to have been dry, and that there is strong anecdotal evidence that Lake Nerrigorang was not dry during the WWII drought.

Addendum 3 to the Pells reports tabulates lake level observations from 1798 to 2011, and provides additional historical lake photographs.
Pells observes that the level of Lake Nerrigorang started falling in about 1992, while the levels of Lakes Couridjah, Werri Berri and Gandangarra did not start dropping significantly until about 1996. Lake Nerrigorang was empty by the end of 2009, while lakes Werri Berri and Gandangarra were empty two years later. Local resident Paul Rackleyf reflects that this behaviour is inconsistent with the historical knowledge in his family; the Rackleyf family bought land around Lake Nerrigorang in about 1926.

Pells reports that he has compelling accounts that the lake levels were very low but not dry during the time of the Federation drought (~1909). He also notes that the Myles Dunphy journals indicate that the lakes were not full, but held a few metres of water from the mid 1920s to the late 1930s. Excerpts from the Miles Dunphy journals are provided in Addendum 3 to the Pells report.

While the Committee may have doubts, it would be prudent and consistent with the guidance of the Precautionary Principle to assume that the recent drying has been more extensive than in the past.

The draft Report acknowledges on page 108 that the recent behaviour of the lakes is cause for concern: "The last 4 months have been very wet. Community concerns that the lakes are not filling, even if not to capacity, seem to have some veracity, especially as the Committee’s observations suggest that Lake Nerrigorang is not filling as much as the other lakes and appears to rapidly decline in level following initial inflows."

The Committee and Pells have put forward different possible explanations for the anomalous behaviour of Lake Nerrigorang. Nonetheless there remains cause for concern for Nerrigorang and the other lakes. The lakes appear to have dried more extensively in the past and the recent drought seems to have been less severe than those associated with the drying of the lakes last century. The lakes became visibly dry during 2011, part of the way through a double La Niña that started in 2010. The recent drying of the lakes seems to have occurred under comparatively mild conditions, relative to those that prevailed when they dried last century.

**Recommendation 6: The Report recognise in the executive summary and the main text that the lakes may have dried more extensively than in the past.**

**Significant Water Removal at Tahmoor Colliery**

Other than a detailed account of water inflows during mine construction the construction in the 1970s, the draft Report pays little attention the level of water removed from Tahmoor Colliery. While reliable records are apparently only available from 2009, there are at least indicative records to 1997 (Figure 41 in the NOW report[8]) and anecdotal reports beyond 1997. Rather than dismiss records prior to 2009, as would appear to be the case, it is incumbent upon the Committee to follow the advice of the Precautionary Principle and recognise and heed the earlier records and anecdotal accounts.

The longwalls of Tahmoor Colliery made their closest approach to the lakes between February 1999 and July 2002. Pells comments that depressurisation effects from dewatering may take some years to propagate to near surface and surface groundwaters.

The draft Report notes on page 226 dewatering volumes of 2 to 4 ML/day from 2009, when longwall 25 was in progress. The low resolution of Figure 8-13 in the draft renders it illegible (likewise some
other figures in the draft), however the same figure is available in Figure 41 of the 2010 NOW report[8] and Figure 4.4 in the Pells report. This graphical depiction of mine make water suggests dewatering of 2 to 8 or more ML/day from 2002, when longwall 19 was underway, and this volume is consistent with anecdotal accounts from miners. Assuming an average 4 ML/day from 2002 to 2009, suggests the removal of some 13 gigalitres of water. This is clearly a substantial amount of water and it would be reasonable to expect significant depressurisation propagating outwards across the overlying strata (Fig. 5).

Tahmoor Colliery has a groundwater extraction licence of 1,642 ML/year for mine dewatering and 4 ML/day would correspond to 1,460 ML/year. Pells and Gilbert and Associates are in agreement that the total (combined) full volume of all of the lakes is 1770 ML. That is, dewatering of 4 ML/day over the course of a year would remove a volume of water close to the total volume held by the lake system when full.

Using deep recharge parameters reported by Gilbert and Associates, the draft Report suggests on page 155 that without recharge (and evaporation) the lakes would naturally drain in about five years. Mine dewatering removes an equivalent volume in one year.

As discussed below, the recharge parameters used by Gilbert and Associates appear to be an order of magnitude greater than those used by Pells, and would appear to be inconsistent with the notion of restrictive strata permeability. Natural drainage to empty, in the absence of recharge and evaporation, would then take decades rather than years.

The draft Report does not mention the anecdotal accounts of significant inflows into the mine, with reports of a need to close off a panel because of flooding. Nor does it mention suggestions that dewatering of 4 ML/day has occurred since the mid 1970s. Nor have the Committee members have visited the mine.

The draft notes that the 65 known bores for the area between the lakes and Tahmoor have entitlements from 1 to 19 ML/year. The draft Report advises an average pump yield of 1.12 L/s (0.113 to 6.69 L/s) which, assuming 24/7 operation, suggests about 0.1 ML/day or 35 ML/year. Though their volumes are small in comparison to water removal at the mine, in general the bores operate in the surface aquifer of the Hawkesbury sandstone. The combination of the bore use and mine pumping clearly removes a very substantial volume of ground water each year.

**Recommendation 7:** The Report recognise there was dewatering at Tahmoor Colliery of between 2 and 8 or more ML/day between 2002 and 2009 and that there are reports of up to 4 or more ML/day for a substantial time before 2002. The Report should put this volume in the context of the above-surface volumes held by the lakes and the volume known to be removed by surface pumping.

**Corrections to Lake Level and Volume Observations Reported by Pells**

At the public meeting held in the Picton offices of Wollondilly Council on May 22 Dr Pells presented an update[3] on his assessment of the drying of the lakes and this included a key correction to survey measurements used to determine lake levels and volumes. As a result the lake levels and volumes reported by Pells match those of Gilbert and Associates. The corrections were made available on the Web in May and June as Addendums 3 and 4 for the Pells report of October
2011. Addendum 4 is provided as an attachment to this submission and was sent to the Committee on July 12.

Table 8.1 in the Gilbert and Associates submission and Table 5.4 in the draft Report no longer represent the data used by Pells. An updated version of that table is provided in Addendum 4 of the Pells report.

The estimate on page 55 of the Gilbert and Associates submission of "... an inferred capacity of approximately 3,600 ML in Pells (2011)." is no longer correct. Likewise the comment on page 155 of the draft Report that "Pells' (2011) lake volume is approximately 3.6 GL ... " is no longer correct. Pells corrected volume is 1770 ML.

The modelling undertaken by Pells has been repeated with amended and additional data. The lakes have been modelled separately, with allowance for bi-directional flows. The updated modelling has reinforced the implications arising from the earlier work.

**Recommendation 8:** The Report recognise and accommodate the corrections to the lake levels and volumes reported in May and June by Pells. The Report accordingly amends its assessment of the accuracy and precision of lake level measurements.

The Value of Modelling

The draft Report is dismissive of the modelling undertaken by Pells and Gilbert and Associates on three grounds; apparent uncertainty in observed lake levels over time, limited data and the complexity of the system being modelled.

The modelling undertaken by Pells and Gilbert and Associates (G&A) is challenged by limited data. The challenges posed by this kind of modelling are widely recognised and Pells is frank about the limitations of his modelling. Modelling may nonetheless provide valuable guidance.

As indicated at the public meeting at Picton in May, Pells has corrected a surveying error in his determination of lake levels. His lake levels and volumes are now in good agreement with those of G&A.

The complexity of the real world is a problem that challenges all modelling, with a relevant example being modelling to understand anthropogenic climate change. Climate change modelling has improved over time and in doing so has reaffirmed, rather than contradicted, earlier understanding and predictions.

Though different tools are used, the modelling undertaken by Pells and G&A is essentially equivalent. Pells optimises his model against the historical data, whereas G&A conversely prefer to optimise with respect to the recent data. The Pells model then shows post 2000 lake levels higher than observed, while conversely G&A show historical levels that are too low. In the context of the emerging evidence and the coincident nearby passage of longwalls of Tahmoor Colliery, the former seems more plausible.

A key parameter in fitting the models to the observations is the natural deep groundwater recharge parameter. The Pells model uses a modest value of 25 mm/year, based on their assessment of strata permeability. It would appear that Gilbert and Associates use a much higher value and that different
values are used for each lake, with values ranging from 300 to 1000 mm/year for recharge from full lakes. Gilbert and Associates report their recharge parameters as kL/day; there is some uncertainty in converting to mm/year as it's not clear what full lake levels have been used and hence what associated surface area values are to be used in making the conversion. Nonetheless it would seem Gilbert and Associates use recharge parameters at least an order of magnitude greater than used by Pells. This is inconsistent with the assumption of restrictive subsurface vertical permeability.

While the 'signal' emerging from the modelling may be weak, it would be prudent to take it seriously and accept that it is pointing towards a water balance anomaly. The modelling incorporates climate, catchment and pumping parameters and accordingly suggests mine dewatering as a plausible explanation for the water balance anomaly. Pells has suggested mine dewatering contributes 10 to 20% of the loss of water from the lakes. Losses of this level could make a significant contribution to the premature drying of the lakes.

The modelling can be improved and progress is being made in modelling against limited data. The assertion in the draft Report on page 155 that "The data uncertainties do not warrant another attempt and nothing would be proved." is unreasonably pessimistic and over-states the expectation of the modelling.

Pells states in Attachment 1 to this submission: "The objective of modelling was not to aspire, with the available data, to prepare a deterministic simulation of water levels, but rather to examine the relationship of water levels against climatic conditions over history."

**Recommendation 9:** The Report recognise and heed the nature, intent, exploratory value and indicative message of the modelling undertaken by Pells. The Report should recommend that effort is made to improve the modelling.

**Ground Water Re-Direction as a Result of Water Removal at Tahmoor Colliery**

While the draft report discusses mining subsidence impacts at some length, it does not consider the possibility of depressurisation across an intact Bald Hill Claystone (BHC) layer and into the Hawkesbury Sandstone arising from dewatering at the nearby mine. The Committee evidently discounts this possibility, confident that the BHC will 'insulate' the Hawkesbury Sandstone from depressurisation effects.

As the draft Report notes, depressurisation is the principal explanation Pells suggests for the water balance anomaly that the modelling points towards. It's a sound suggestion; the possibility of depressurisation across the BHC has been an on-going concern for the NSW Planning and Commission[9] and was a concern for the Southern Coalfields Inquiry[10] and the Reynolds Inquiry.[11] While the PAC accepts that the BHC may act as a confining layer, it clearly has reservations and points out that it is unreasonable to assume the character of the BHC is uniform across the Southern Coalfield.

As Pells notes with resignation in the manuscript[12] provided as Attachment 4 to this submission; "Impacts of underground coal mining on near-surface groundwater, and surface waters, in the Sydney Basin have elicited strong opposing views for about fifty years. Now those opposing views extend to coal seam gas (CSG) extraction. A link between these two activities is that both require substantial depressurisation and removal of groundwater from the coal seam. The strongly
opposing views were encapsulated in the 1974-1975 Reynolds Inquiry into “Coal Mining Under or in the Vicinity of the Stored Waters of the Nepean, Avon, Cordeaux, Cataract and Woronora Reservoirs”. For that Inquiry Messrs Orchard, Wardell, Williamson and Morton, working as consultants to the mining industry, expressed strong views that there was no downward flow through the Bald Hill Claystone and underlying Narrabeen rocks to the workings in the Bulli and Wongawilli seams. Equally, Professor John Knill and Messrs Williamson and Winchup, working on behalf of the Metropolitan Water Sewerage and Drainage Board concluded that downward seepage from the reservoirs was occurring and constituted a significant risk.”

As noted further within, Heritage Computing and Parsons-Brinckerhoff share the view that the Bald Hill Claystone and other strata preclude vertical flow a consequence of dewatering and depressurisation.

![Diagram](image)

**Figure 5.** Pells modelling showing depressurisation radiating outwards from Tahmoor Colliery after 1 year. Taken from the first Addendum to the Pells Report.[3]

Pells also states “In Part 1 of this paper, it is shown that in the Sydney Basin, even if no fracturing takes place, the capacity for saturated vertical seepage into lower, depressurised, strata is typically higher than the available recharge. It follows, then, that depressurisation will continue to propagate outwards from the depressurised strata throughout the period of dewatering. Where fracturing occurs, the capacity for saturated vertical seepage will be increased. Hence, while an initial response and recovery may be observed, an ongoing growth in impacts is expected during the operation of mines in the Sydney basin.”[12] Figure 5 shows a Pells simulation of depressurisation propagating outwards from Tahmoor Colliery.[3]

The draft Report notes relevant evidence, such as on page 178 (where Hawkesbury Sandstone and the colluvium appear to have been transposed); “The water level in the colluvium (GW075409/2) is about 8 m lower than in the Hawkesbury Sandstone (GW075409/1), indicating a downward hydraulic gradient beneath Lake Couridjah.” There is however no further comment in the draft report on this substantial downward gradient. In contrast, the draft Report does emphasis elsewhere that depressurisation of the Hawkesbury Sandstone has steepened the hydraulic gradient to the east. That is, it would seem the Committee does not accept that depressurisation will traverse the Bald Hill Claystone.

The draft equivocates in observing “the Bald Hill Claystone was a significant aquitard, although most recent data show partial depressurisation but this may be due to equilibration issues of the VWP”. Likewise “In VWP TNC29, depressurisation has been observed in all aquifers and aquitards, with a maximum of 17.7 m in the Bald Hill Claystone and 13.2 m in
the lower Hawkesbury Sandstone, although Geoterra (2011) attribute the majority of the reduction to equilibration of the VWP with surrounding formation after installation." Like Heritage Computing, Gilbert and Associates, Geoterra provides consultancy services to the mining industry.

Nonetheless, the report states “partial depressurisation of the Hawkesbury Sandstone has occurred due to longwall mining.”

Taking into consideration industry concerns regarding piezometer reliability, the Precautionary Principle requires that the benefit of the doubt must be given to the possibility of depressurisation across the BHC and a consequential vertical groundwater flow component from the Hawkesbury sandstone towards the mine below.

On pages 186 to 188 and 230 to 231 the draft Report notes water loss reported by bore owners, with the mining company compensating in one instance. On page 188 the draft Report appears to attribute the water loss to geology; “It is worth noting that a large number of the private bores that reported a reduction in water level and/or yield appear to be aligned with the Thirlmere Monocline and close to the dyke reported by Xstrata in Longwalls 20 and 21. The combination of structures may have some impact on the hydraulic gradients and flow rates within the Hawkesbury Sandstone.”

Yet the report also states on page 232 that “private bores located approximately 0.6 km from Lake Gandangarra and Lake Couridjah reported decline in yields/water levels when mining came within 1 km of their properties.”

Pells provides a detailed account of bore inspections in Addendum 3 to his report on the lakes.[3]

Given the compelling circumstantial evidence, it is very puzzling that the draft Report does not clearly state that there is cause for concern that depressurisation associated with mine dewatering is changing the velocity of ground water flow, with a vertical component across the BHC towards the mine. Even if the Committee doubts the strength of the evidence, the Precautionary Principle would advise that the available evidence is cause for concern and requires a prudent response.

**Recommendation 10:** The Report clearly recognise and accept that depressurisation associated with mine dewatering is changing the velocity of ground water flow, introducing a vertical component across the Bald Hill Claystone towards the mine. This should be stated in the executive summary and the main text.

---

**The Character of the Bald Hill Claystone According to Pells**

The draft Report evidently accepts the view that across the Southern Coalfields the Bald Hill Claystone is a very restrictive aquitard.

On page 45 the Pells report[3] observes the following; “It can be seen that the measured packer test permeability values for the Bald Hill Claystone fall within the ranges measured in the Hawkesbury Sandstone and the Narrabeen Formation. In assessing these results cognisance must be taken of the fact that where boreholes do not intercept joints, permeability is largely controlled by the near horizontal bedding planes. However, in assessing vertical permeability consideration must be given to the following evidence that the Bald Hill Claystone contains many discontinuities. The Bald Hill Claystone contains as many as eight soil profiles25 (ie. eight superimposed palaeosols), is fissured
and jointed, and is transgressed (in places) by faults and igneous intrusions (see Figures 3.11 to 3.13). The Pells report provides comparative data in Figures 3.9 and 3.10 on page 45.

Further detail and insight is provided in the Appendix to the Pells Report, including experimental work to assess the character of the BHC. This material has provided the basis for two manuscripts that have been accepted for publication in Australian Geomechanics, with the title ‘Impacts of Longwall Mining and Coal Seam Gas Extraction on Groundwater Regimes in the Sydney Basin; Part 1 and Part 2’.[12] The manuscripts provide further insights into the complex and variable character of the BHC, and further question its role as a confining layer. The manuscripts are provided as Attachments 3 and 4 to this submission, and were sent to the Committee via an email on July 12, together with Addendum 4 to the Pells Report which updates lake level observations and modelling results. Addendum 4 is provided as Attachment 2 to this submission.

Table 1 in Attachment 4[3] for this submission lists permeabilities for the BHC, Hawkesbury and Narrabeen formations at the Tahmoor Colliery published by Holla in 1989.[12,13] They are consistent with the characteristics determined by Pells.

The recent work by Pells[12] on the BHC suggests the view of the BHC adopted by Heritage Computing, Parsons-Brinkerhoff and others is overly simplistic, as is the notion of confined zones. Pells notes that the Bald Hill Claystone contains as many as eight soil profiles, is fissured and jointed, and is transgressed in places by faults and igneous intrusions. Pells points out the following statement in the draft NSW Government Aquifer Interference Policy of March 2012:

“A groundwater system is any type of saturated geological formation that can yield anywhere from low to high volumes of water. For the purpose of this Policy the term aquifer has the same meaning as groundwater system ...”

This perspective is evidently consistent with the view that in reality the differentiation between aquicludes, aquitards and aquifers is unclear. Pells tabulates permeabilities that indicate the similarity of the Bald Hill Claystone and sandstone strata.

**Recommendation 11:** The Report clearly recognise and accept the complex and variable character of the Bald Hill Claystone and that its permeability overlaps with that of the Hawkesbury Sandstone and other strata.

**De-watering Impacts According to Heritage Computing and Parsons-Brinkerhoff**

In their report[2] for the Bulli Seam Operations Project, the NSW Planning and Assessment Commission (PAC) is critical of the groundwater modelling undertaken by Heritage Computing on behalf of BHP-B, commenting for instance on their assessment of permeability values for subsurface strata:

“The density of testing to assess the permeability of subsurface strata (a key property which underpins a groundwater model and the subsequent impact predictions), was entirely inadequate for a project of the scale and magnitude envisaged. Only one borehole was subjected to permeability testing in a Project Area comprising some 220 km2 and no data were presented in the EA to support such testing. Rather, permeabilities that were subsequently adopted in computer based simulations of the BSO Base Case longwall panel layout, were apparently informed by SCA
studies at Dendrobium Mine 12 km to the south, Kangaroo some 30 km distant, Metropolitan Mine a few kilometres to the east (one borehole), and Mangrove Mountain more than 100 km to the north-east;”

Parsons-Brinckerhoff (PB) contributed a ground water assessment[14] for the Environmental Assessment (EA) for AGL’s proposed expansion of the Camden CSG Project. PB state

“This review concludes that the presence of extensive and thick claystone formations in the stratigraphic sequence that overlies the Illawarra coal measures in the project area will impede the vertical flow of groundwater such that overlying aquifer zones will be hydraulically isolated, experiencing little, if any drawdown impact related to depressurisation of the coal measures.”

PB follow Heritage Computing in assuming permeabilities are transferable across the Sydney Basin;

“With the exception of measurements carried out in the target coal seams by AGL, there are no available permeability data for aquifer units specifically within the project area. However given the lateral extent and lack of structural complexity of water bearing units in the Sydney Basin it is valid to base estimates of aquifer parameters on tests carried out elsewhere in the Basin.”

Campbelltown City Council expressed frustration with the EA as follows[15];

“The EA is not considered to have complied with the Director General’s Requirements for the project regarding the ‘assessment of the potential impacts of the project on surface and groundwater resources (including salinity), the assessment of cumulative impacts on air and water quality and impacts on biodiversity; The EA is not considered to have adequately assessed potential impacts associated with the proposed development on surface and groundwaters, and biodiversity in particular;

Council commissioned WorleyParsons (WP) to undertake review[15(b)] of the EA and in doing so WP highlighted the following risk;

“The production of CSM requires the reduction of hydrostatic pressure in the target coal seams of the Illawarra Coal Measures, through groundwater extraction. Consequently, the potentiometric surface (or the level of the groundwater within the confined space of the coal seams) will be lowered within an area of influence of CSM production. Vertical hydraulic gradients will also be affected, creating a pressure differential between the coal seams and overlying and underlying units. The pressure differential has the potential to transmit groundwater vertically from overlying and underlying aquifers towards the coal seams through intervening units (aquitards) or along open pathways. The magnitude of the groundwater transfer is governed by the pressure differential between the units and the ability of the intervening layer to transmit the groundwater vertically; a function of the unit’s vertical hydraulic conductivity and thickness.”

WP determine; “The assessment of the potential impacts and risks of groundwater extraction during CSM production is not considered to be presented in sufficient detail in the EA document to enable a comprehensive peer review or to satisfy the DR Requirements of a detailed groundwater impact assessment.”

“The EA document indicates that the relatively impermeable overlying Narrabeen Group will aid in confining the impacts of dewatering to the coal measures. It would be prudent for the EA to justify
this statement through a simple analytical assessment and accompanying sensitivity analysis to capture the variability in hydraulic properties. This analysis would assess the potential for water movement to the production zone from overlying and underlying units through intervening aquitards and the anticipated time lags."

The kind of analysis WP recommend has been undertaken by Pells Consulting for Thirlmere Lakes[3], including an assessment of permeability ranges and possible water movement following watering. Earlier this year Pells did likewise in undertaking a review of PB’s groundwater assessment for AGL’s proposed Gloucester CSG project.[16] PB again determine that surface and near surface waters are insulated from depressurisation impacts:

"The interburden confining units are effective confining units that separate shallow groundwater aquifers from deep coal seam water bearing zones." And "The low permeability interburden units are locally saturated, but generally act as confining layers between and overlying the coal seams. The layered aquitards of the interburden units create separate and distinct groundwater systems with no connection evident between the deeper coal seam water bearing zones and the shallow rock and alluvial aquifers"

A comprehensive analysis by Pells finds otherwise[17]: "The interpretations in the report are flawed and it does not demonstrate that depressurisation at coal seam levels will not cause alteration to the directions of flow and the pressure system in the near surface groundwater regime, hence affecting surface waters." And "The monitoring period is too short to allow conclusions to be reached about the natural environment and provides no monitoring data relevant to groundwater behaviour under CSG Stage 1 extraction." And "The report provides no calculations of any kind in respect to changes in groundwater flows, pressures and extraction water."

Pells observes;

"While the terms 'aquifer', 'connected' and 'disconnected' can sometimes aid communication, zones and layers of rock of different permeability, storage and chemical properties interact as a continuum. The interactions may be quite fast, or very slow; but they will occur and the real question we must address is: How long will it take for man-induced changes to work their way through a groundwater system?"

Pells finds PB’s analysis of rainfall helpfully limited in scope:

"It is clear that the rainfall record used by PB does not cover the quite substantial variations that have occurred since 1889. Therefore, it is reasonable to think that conclusions drawn by PB from the post-1976 records are not appropriate, even down to factual matters such as average annual rainfall."

A concern with the draft Report for the Thirlmere Lakes Inquiry is that when considering local rainfall it focuses its attention on post 1989 records.

Within a more limited scope, SKM also reviewed PB’s groundwater assessment and conclude as follows[18];

"In some instances it is considered that the PB (2012) study has drawn inaccurate conclusions from the data or omitted some work which would improve conceptual understanding. These generally fall into categories of: connectivity between deep and shallow systems, recharge and discharge processes, characterisation of vertical hydraulic conductivity and specific improvements that can be made to the conceptual model."

17
Committee member Dr Wendy Mclean contributed to the PB groundwater assessment and is a signatory on the PB document, which was signed off in January 2012 — some months into the Thirlmere Inquiry.

**Dating the Water**

As Pells points out in the attached manuscripts[12] the character of the BHC have been in question since the Reynolds Inquiry. It is remarkable then that research has still not been undertaken to properly assess the region by region character of the BHC. On page 233 the draft Report observes the value of dating groundwater, but this is not explicitly included in the recommendations of the report. In order to understand the character and role of overlying strata and the influence of the mine on groundwater flows, ground water should be dated at various depths above the coal seams and at varying distances from the mine.

Dating the water will inform the modelling and help distinguish the influence of the mine from other influences on the water levels of the lakes.

| **Recommendation 12:** The Report explicitly recommend that ground water is to be dated at various depths above the coal seams and at varying distances from the mine. |

**Conclusion**

There is emerging evidence of vertical groundwater gradients, there are the reports of bore water loss, there is the passage nearby of longwalls, there are indications of significant and sustained levels of water removal from the coal mine, there is evidence of the complex and variable character of the Bald Hill Claystone with permeabilities overlapping with those of Hawkesbury Sandstone, there is the plausibility of strata depressurisation propagating outwards from the mine, there is an indicative signal in the modelling coincident with the passage of the longwalls and there is evidence that the lakes have dried during a comparatively mild dry period. These observations reasonably call into question the Committee’s judgement that the mine has not played a significant role in a premature drying of the ancient and World Heritage listed Thirlmere Lakes. The emerging evidence, circumstances and modelling suggest otherwise.

The Committee unreasonably dismisses the message of the modelling and ignores the prospects for improved modelling. The Committee unreasonably despairs at the challenge of distinguishing the influence of water removal at the mine from water removal at the surface and the influence of anthropogenic climate change.

There are good grounds for concluding that while natural climate effects are the primary cause of the lakes drying, a difference this time is that water removal at the Tahmoor Colliery, water removal at the surface and anthropogenic climate change have together contributed to the lakes drying prematurely.

As the Committee observes, little can be done to mitigate the effects of natural climate influences that have operated for millennia, but action can be taken to reduce the influence of the mine and surface pumping. Addressing anthropogenic climate change is more problematic and the future of
the lakes looks bleak. Surely they should nonetheless be protected from other harmful human activity?

**Recommendation 13:** The Report clearly state in the executive summary and in the main text that there is cause for serious concern that the Tahmoor Colliery has made a significant contribution to a premature drying of the Thirlmere Lakes. Response recommendations should be made accordingly.

Noting the advice of the Precautionary Principle, the Report should state that this conclusion is reached given the following observations: the emerging evidence of vertical groundwater gradients, reports of bore water loss; the passage nearby of longwalls; the indications of significant and sustained levels of water removal from the coal mine, the evidence of the complex and variable character of the Bald Hill Claystone with permeabilities overlapping with those of Hawkesbury Sandstone; the plausibility of strata depressurisation propagating outwards from the mine; the indicative signal in the modelling coincident with the passage of the longwalls; and the evidence that the lakes have dried during a comparatively mild dry period.
List of Recommendations

Recommendation 1: The Report adopt best practice and heed the advice of the Precautionary Principle. Where appropriate the report should indicate where the Precautionary Principle has been applied.

Recommendation 2: The Report should clearly state that Dr Mclean is an employee of Parsons-Brinckerhoff, a mining industry consultancy, and has undertaken work in that capacity during the course of the Inquiry that is related to the consideration of the impact of Tahmoor Colliery on the drying of Thirlmere Lakes.

Recommendation 3: The Report should clearly recognise the potential for bias in proponent funded assessments.

Recommendation 4: The Report adopts a recognised definition of drought and distinguishes the term ‘drought’ from ‘dry period’ and ‘drought dominated regime’. The Report should accordingly identify and distinguish dry periods and periods of drought.

Recommendation 5: The Report recognises in the executive summary and the main text that the lakes have dried during a comparatively mild drought period prematurely and have in effect dried prematurely. The Report should include a comparative assessment of the recent drought using the method employed by the Bureau of Meteorology or the Standardised Precipitation Index.

Recommendation 6: The Report recognise in the executive summary and the main text that the lakes may have dried more extensively than in the past.

Recommendation 7: The Report recognise there was dewatering at Tahmoor Colliery of between 2 and 8 or more ML/day between 2002 and 2009 and that there are reports of up to 4 or more ML/day for a substantial time before 2002. The Report should put this volume in the context of the above-surface volumes held by the lakes and the volume known to be removed by surface pumping.

Recommendation 8: The Report recognise and accommodate the corrections to the lake levels and volumes reported in May and June by Pells. The Report accordingly amends its assessment of the accuracy and precision of lake level measurements.

Recommendation 9: The Report recognise and heed the nature, intent, exploratory value and indicative message of the modelling undertaken by Pells. The Report should recommend that effort is made to improve the modelling.

Recommendation 10: The Report clearly recognise and accept that depressurisation associated with mine dewatering is changing the velocity of ground water flow, to introduce a vertical component across the Bald Hill Claystone towards the mine

Recommendation 11: The Report clearly recognise and accept the complex and variable character of the Bald Hill Claystone and that its permeability overlaps with that of the Hawkesbury Sandstone and other strata.

Recommendation 12: The Report explicitly recommend that ground water is to be dated at various depths above the coal seams and at varying distances from the mine.
**Recommendation 13:** The Report clearly state in the executive summary and in the main text that there is cause for serious concern that the Tahmoor Colliery has made a significant contribution to a premature drying of the Thirlmere Lakes. Response recommendations should be made accordingly.

Noting the advice of the Precautionary Principle, the Report should state that this conclusion is reached given the following observations; the emerging evidence of vertical groundwater gradients, reports of bore water loss; the passage nearby of longwalls; the indications of significant and sustained levels of water removal from the coal mine, the evidence of the complex and variable character of the Bald Hill Claystone with permeabilities overlapping with those of Hawkesbury Sandstone; the plausibility of strata depressurisation propagating outwards from the mine; the indicative signal in the modelling coincident with the passage of the longwalls; and the evidence that the lakes have dried during a comparatively mild dry period.
References


13. *Investigation into Sub-surface Subsidence*. Holla, L. (1989); End of Grant Report No 689, Commonwealth Department of Primary Industries and Energy, Canberra


18. Gloucester Coal Seam Gas Project Peer Review of Groundwater Studies - Report to Gloucester Community Consultative Committee; Dr Richard Evans; Sinclair Knight Merz Pty Ltd. May 2012.