OTWAY WATER BOOK 43

Modelling Groundwater Impacts, Past, Present & Into the Future.

(2018)

In Memory of a mate, Fletcher (2005-2017).

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Malcolm Gardiner

Email: otwaywater@yahoo.com.au www.otwaywater.com.au

A **2010** Victorian Auditor-General's report on the management of Victoria's groundwater resources had this to say...

"***The Department of Sustainability and Environment (DSE) and water corporations do not know whether groundwater use is sustainable***."(3)

Little has changed if the management of the Barwon Downs Borefield is used as an example.

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INTRODUCTION.

The aim of Otway Water Book 43 is to review some of the material presented in Jacobs' "***Barwon Downs Hydrological Studies 2016-2017, Groundwater Model Predictive Scenarios Report, 1 Draft, 18 December 2017, Barwon Water***."(9)

Any predictions produced from modelling are only as good as the material fed into the model. Input "faulty" data and the model will produce "faulty" results.

> The majority of the studies from which the data being fed into the Jacobs' groundwater model, do not follow the most basic processes normally followed when conducting scientific investigations. As a consequence the modelled results will be of doubtful value.
>
> ***Critical Problems with the SKM/Jacobs Work.***
>
> - The majority of the studies from which the data being fed into the groundwater model, have not followed the most basic processes normally followed when conducting scientific investigations, with:
>   - A. An understanding that rigorous scientific procedure insists that before any analysis of data is attempted the data is registered with an independent body including the name(s) of the researcher and the date data was collected. There is no evidence since 2008, in any of the SKM/Jacobs studies indicating that this procedure has been followed.
>   - B. Poor literature search excluding key studies.
>   - C. Omission of key variables.
>   - D. Existing problems and or dangers downgraded, excluded or ignored.
>   - E. Existing data unjustifiably excluded.
>   - F. Existing data corrupted.
>   - G. Existing data replaced with assumptions.
>   - H. State Government Policy ignored until 2015, and then,
>   - I. objectives are pursued following the letter of the "law" not the intent of the "law."
>   - J. Limitations of recommendations and proposals not clearly defined.
>   - K. Making assumptions, drawing conclusions and making predictions from faulty and limited data.
>   - L. Presenting half truths and prevarication.

M. Using limited data gained starting at a 2014 baseline with the exclusion of data collected pre 2014.
N. Reluctance to admit errors.
O. Failure to correct errors.
P. Failure to modify/amend studies with corrections.
Q. Failure to recognise contradictory statements.
R. Failure to have studies peer reviewed from outside the Jacobs regime.
S. In other instances failure by Jacobs peer reviewers to adequately scrutinise their work.

2. A most intriguing issue with Jacobs hydrogeological discussion and studies is the limited use made regarding local farmers' years of observations. MacKay[(1)] writes about cutting edge science needing to recognise that the lay person can identify simple but precise indicators of the status of groundwater-dependent ecosystems. Eamus et al.[(2)] states that estimations of water regimes required by an ecosystem are developed through strategic scientific research and through the application of local knowledge based on many years of observation.

The limited use made of local knowledge is a short fall in Jacobs' work that could have gone a long way to limiting the amount of assumptions, predictions and guesswork made.

3. Too often the local knowledge that is volunteered is...

a. denied as applicable,
b. and if studied, then presented as an argument placing doubt on the veracity of the local knowledge, and
c. if local knowledge is given any acknowledgement of mistakes made, the original work is seldom rewritten.

4. With a "new start" to data collection beginning in 2014 little mention is made of known dangers due to pre 2014 impacts.

5. There has been scant discussion on what type of future impacts could be expected as a result of groundwater extraction that has taken place pre 2014. The 2017 predictive modelling report has its basis built upon data collected since 2014.

In regard to this "*Groundwater Model Predictive Scenarios Report*" it is pleasing in one sense to see it being distributed as a DRAFT FOR DISCUSSION. In another sense, by this stage in the application for the renewal of the groundwater extraction licence process it can be expected that there should only be minor tweaking of the report.

The draft of this introduction to Book 43 was written before opening the 18 December 2017 Report.

The introduction was finished after another unsuccessful attempt to meet with the Minister for Water, Lisa Neville, to discuss local community concerns regarding the management of water resources in the Barwon River and Gellibrand River catchments. Three members of LAWROC Landcare Group travelled to Melbourne for this meeting under the impression that the Minister would be present. Unfortunately this was not the case, another disappointment and opportunity missed.

Data Fed Into the Model.

The results of a multitude of SKM and Jacobs reports provide the basis of the data fed into the modelling program(s). Unfortunately, it is these reports that contain the faults as mentioned in the introduction to this book.

These reports include:

- 2002 Ecology Australia and SKM vegetation study – part of 2004 licence renewal
- 2009 SKM licence condition vegetation study
- 2012 SKM Barwon Downs New Monitoring Program.
- 2013 Revised SKM Barwon Downs New Monitoring Program.
- 2015 Jacobs licence condition vegetation study.
- 28 August 2015 Review of Conceptual Model at Numerical Model Boundaries.
- 14 September 2015 Potential Acid Sulphate Soils Filed Investigation.
- 5 August 2016 Installations of New Monitoring Assets.
- 16 June 2017 Numerical Model Calibration and Historical Impacts.
- 16 September 2016 recharge Rate Assessment.
- 21 February 2017 PASS Baseline Assessment.
- 17 March 2017 Boundary Creek aquatic ecology investigation.
- 22 March 2017 Integration Report.
- 9 November 2017 Yeodene Swamp Study.

DISCUSSION.

Pleasing to Note.

It is pleasing in one sense that this modelling report has been distributed for discussion. However, considering that by mid June 2017 the timeline for the lodging of the application for the renewal of the groundwater extraction licence was set for the end of November 2017, it could be expected that the application would be close at hand. It is now May 2018 and looks no closer. It could also be expected that Jacobs' recommendations would have been concluded by this stage, especially considering the often stated statement that scientific rigor and technical expertise has been applied to the process. The model being used has passed the highest possible accreditation, so why the report has not been released as a Final rather than a Draft is also difficult to understand. Perhaps it is being left up to the lay person to proof read the report and come up with "mistakes" made.

For example:

"***Groundwater levels close to the borefield have recovered approximately 80% since 2010 when the borefield was last used.***"(9)

(Page 78, Conclusions and recommendations)

Not strictly correct. Between April 2016 and September 2016 the borefield was used to extract 3,267,000,000 litres.

"***Groundwater levels are predicted to reach 90% recovery within 10 years if there was no future pumping.***"(9) (Page 78, Conclusions and recommendations)

How experts in hydrogeology could make these two rather rash statements considering their qualifications, expertise and readily available data, seems quite extraordinary.

For example:

Barwon Water extracts water from three aquifers in the Lower Tertiary Aquifer Formation - the Mepunga, the Dilwyn and the Pebble Point aquifers.(4) On page 39 of the Jacobs report Table 3-2 defines the model layer structure. There are 7 layers defined. The Mepunga Aquifer is not included in these 7 layers. In earlier models there were only 5 layers included. The Barwon Water yearly report to Southern Rural Water maps out the residual drawdown for the three aquifers they pump from. The Mepunga is one of them.(4) Using the 2016-2017 Barwon Water report, the following table below, has been compiled.

This table sows the recovery of groundwater levels in the one dimensional vertical sense. The negative numbers indicated the amount of drop in the water table from pre groundwater extraction time. For example the Mepunga Aquifer was drawn down to approximately 22 metres and has recovered up to the 15 metre mark, with still approximately 7 metres to rise/recover.

Aquifer Layer	Approximate maximum Drawdown	Recovery at June 2017	Still to recover	% recovered by 2017	80% recovery level would be...
Mepunga	-22m	-15m	7m	68.2%	-6m
Dilwyn	-50m	-15m	35m	30%	-10m
Pebble Point	-50m	-24m	26m	48%	-10m

Data Source: **Barwon Water Annual reports to Southern Rural Water**.

Of the three aquifer groundwater levels getting close to a recovery of 80% are those found in the Mepunga Aquifer at ~ 68%. However, to be accurate groundwater extraction creates a cone of depression that requires recovery to be calculated in the three dimensional sense i.e. volumetric, not in the lineal sense of one dimension. To better explain this the following extract is taken from Otway Book 35.

FILLING the CONES of DEPRESSION

Once groundwater is stopped or rainfall exceeds extraction and or vertical leakage occurs, then the cone of depression begins to fill up. Although the depression formed is not a regular shaped cone the figure and calculations below illustrate how measuring recovery in the vertical plane can be deceiving.

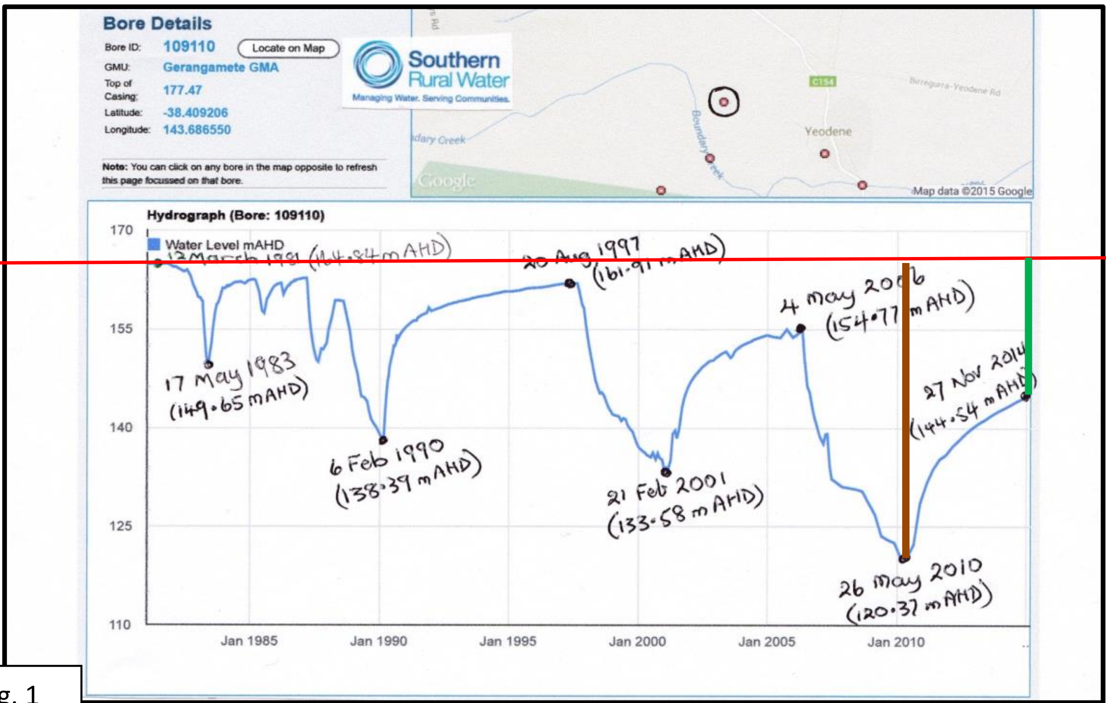
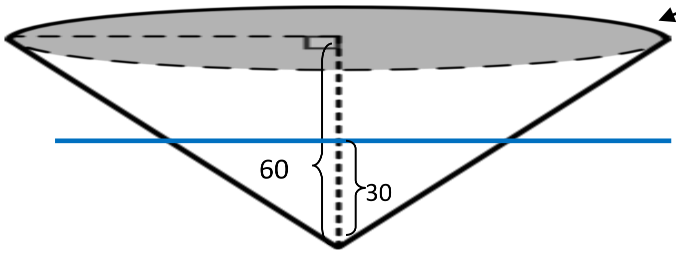


Fig. 1

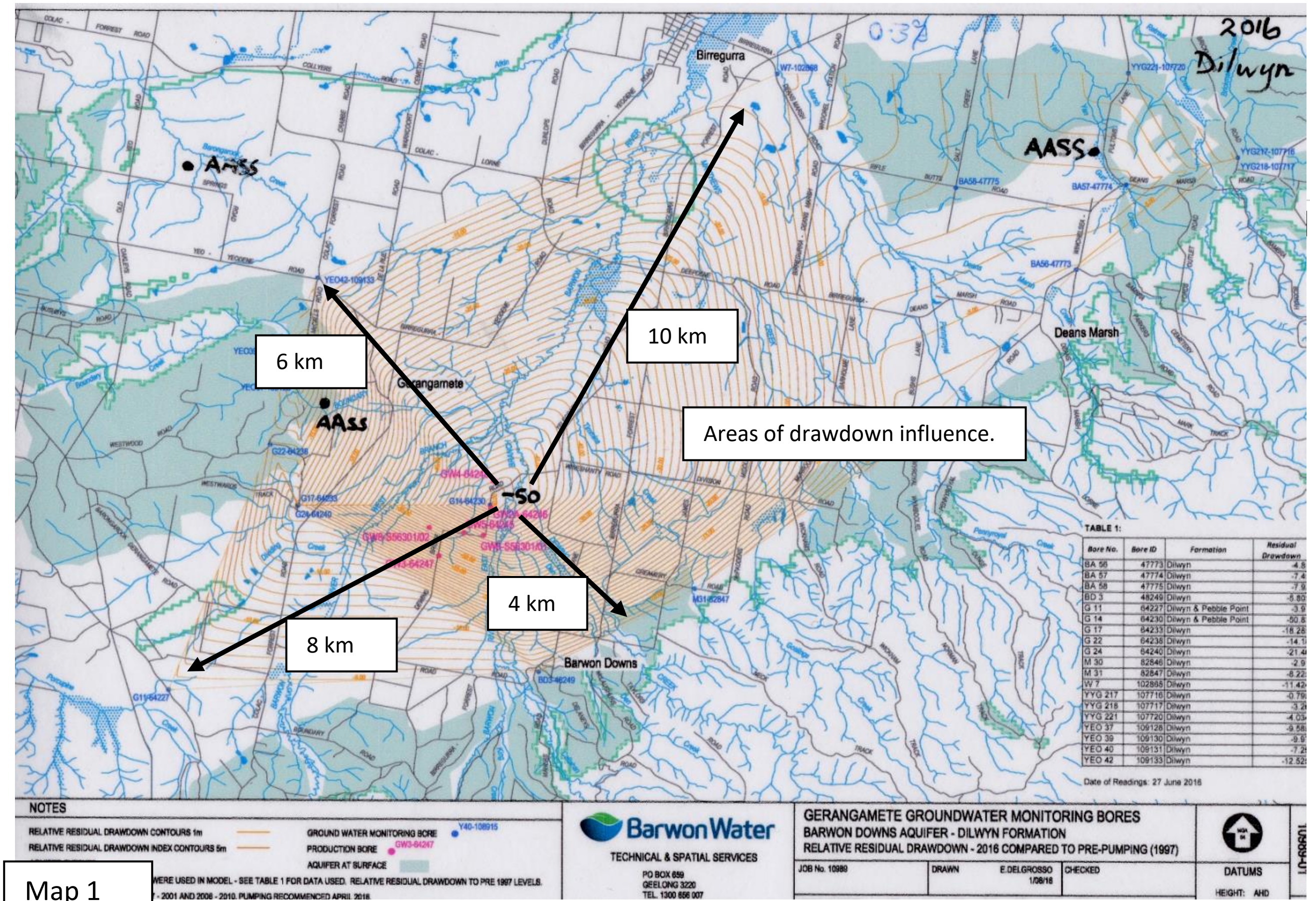
By the end of May 2010 the cumulative drawdown impact from groundwater extraction at observation bore 109110 was approximately 44 metres (brown line, Fig. 1, page 8). Pumping stopped in 2010 and the vertical water level recovered on the graph by approximately 24 metres (green line) by the end of November 2014. This could give the impression that the aquifer has recovered by 50%. This is not the case using the two dimensional vertical plane, and the distortion in the volumetric sense is even more pronounced.



Area of influence (grey shaded area).

This 50% rise in the watertable equates to 12.5% in volumetric terms.

The depth of the cones at the Barwon Downs Borefield went down to approximately 60 metres before pumping was stopped. If the influence spread out uniformly with a radius of 1000 metres a vertical one dimension recovery of 24 m would equate to 6.4% volumetric recovery. For the water table to rise vertically by 50% the volumetric recovery would be only 12.5%. These figures are applicable to a rigid cone with a 1 kilometre radius and are simplistic and indicative only, as the cone of depression caused by the Barwon Downs Borefield does not stay constant; is parabolic and affected by irregular topography. In some directions the radius of the cone of drawdown is around 4 kilometres while in others it is over 10 kilometres. Realistically the volumetric recovery could be significantly less than 12.5%.



Map 1

The red lines indicate the area of drawdown influence as at July 2016 and has a much wider spread than the 1 km radius used in the calculations above.

To further emphasise how easy it is to gain the wrong impression from a one dimensional vertical recovery a Barwon Water representative had this to say after the water tables in the Lower Tertiary Aquifers had risen by approximately half. "***Latest figures from Barwon Water's comprehensive monitoring program show groundwater levels in the area have recovered significantly since the borefield was last operated.***" (Letter to Colac Herald Editor from Barwon Water representative, Friday 18 March 2016.) At this date the Dilwyn Aquifer had recovered to -16 metres before a 2900 ML extraction between April and June, dropped it back down to -50 metres as seen in the map above.

The earliest map available of the drawdown area of influenced goes back to 2002. Since this map was produced every yearly map has shown that the aquifers have never recovered to pre groundwater extraction levels. The influence of drawdown has been taking place for at least 30 years.

How the December 2017 Jacobs model report is able to contain a statement saying the... "***Groundwater levels close to the borefield have recovered approximately 80% since 2010 when the borefield was last used.***" has not been explained. Data from Barwon Water reports suggest that a serious miscalculation has been made. This three dimensional recovery scenario has been brought up at the Barwon Downs Groundwater Community Reference Group meetings. In explanation to the Group an example using a farmer's empty dam was cited. The dam will quickly fill up in the bottom low volume sections but take a significantly longer time to fill the higher sections as the volume of water needed increases. Despite this discussion Jacobs still reports in December 2017, an 80% recovery when this is not the case. To then state "***Groundwater levels are predicted to reach 90% recovery within 10years if there is no future pumping.***" Further compounds this misconception.

Recovery at the Extremities

"***Typical of an aquifer recovery, the rate of recovery is slower further away from the borefield. At Boundary Creek, groundwater levels would take between 20 -30 years to recover if there was no future pumping.***"(Page 1)

The cone of depression at Kawarren believed to be caused from pumping at the Barwon Downs Borefield; the continued drop of the hydrographs down the Ten Mile Creek groundwater flowpath; the drop in flows in Loves Creek and the decreased flows in the Gellibrand River are all at the extremity of the borefield's influence. As the watertable at the centre of the cone fills groundwater from further and further away is drawn back into the void. If the statement above has any veracity then the impacts in the Gellibrand River Catchment will continue for some considerable time and take much more than 20-30 years to recover. This is further emphasised in Jacobs 28 August 2015 report where it states... "***...at distance from the borefield in outcrop areas, groundwater levels in 2012 were lower than in 2010 due to the <u>continued expansion of the drawdown</u> cone at large distances from the borefield after cessation of pumping.***" Major pumping stopped in 2010 yet the expansion of the drawdown cone has continued.

How this statement "***Predicted drawdown as a result of potential future pumping is typically less than the predicted drawdown from historic pumping.***"(Page 1), can be made is extraordinary especially when the historical impacts far exceed the predicted impacts. Perhaps modelling extraction rates at 4,000ML/year is the reason for this discrepancy when in reality past extractions per year were many times more than this.

In 2014 the Barwon Water Groundwater Community Reference Group was told that there were enough observation bores and data available to determine the impacts from the borefield on the Ten Mile Creek groundwater flowpath, just as there should have been enough data available to determine the historical drawdown from pumping. To rely on modelling to predict what the historical drawdown from pumping was, seems quite extraordinary, when the observable data exists. There is something significantly lacking if the historical drawdown cannot be accurately determined from observable data.

Watertable Aquifers.

Only in recent times has it been recognised and accepted that summer surface water in perennial creeks and groundwater are the same resource. The connectedness is now well understood and appropriate management strategies can and should be applied. To no longer regard groundwater discharge into creeks and groundwater extraction from bores as two distinct resources, is welcome news. However, in a similar way that the same water was calculated twice, leading to serious miscalculations, Jacobs appears to be making similar mistakes by breaking groundwater down into various isolated components. The interrelation and connectedness of water movement within the various structural layers of the earth is being overlooked.

"***The water table in the model is the uppermost saturated layer which could be the aquifer, aquitard or bedrock. Local alluvial aquifers present throughout the study area associated with rivers and creeks are not represented in the model as they are localised and not continuous.***"Pages 1 and 78)

Even the alluvial aquifers could be where the watertable is at its uppermost, especially if the potentiometric watertable level of the underlying layers is higher than the alluvial aquifer. In this case the interconnectedness should be a given fact, and the state and behaviour of the alluvial aquifer is vital to gaining an accurate and over arching understanding of what is taking place. This data should be fed into the model not discounted. Despite alluvial aquifers being referred to at least 29 times in the first 15 pages of the 2016-2017 report(9)

"***These local aquifers are not included in the regional groundwater model and consequently drawdown in these shallow local aquifers is not represented.***"

These shallow aquifers are part of the system and should not be seen as insignificant. At one stage in the report recognition is given that there will be impact in the alluvial aquifers but "***... can be considered to be an upper estimate of the drawdown that could be experienced in the local alluvial aquifers.***"(9)

The fact that Jacobs states that shallow alluvial aquifers are present at each of the vegetation and Acid Sulfate Soil sites, and, that the vegetation and ASS studies have contributed to the parameters set in the modelling, it is quite extraordinary how the shallow local alluvial aquifers and any impact on these, has been omitted from the modelling. "***Shallow alluvial aquifers are present***

at each of the vegetation monitoring locations and the acid sulphate soils monitoring locations."[9] There may be a lateral disconnection but there most certainly can be a vertical connection to watertables and other aquifers, especially if there is a drawdown impact from the pumping in the structures underlaying the alluvial aquifers.

Strangely alluvial aquifers have never been referred to in any of the studies carried out pre 2014, or, any distinction made to the significance of these aquifers. Perhaps these local shallow alluvial aquifers are what were referred to in the 2004 licence renewal process, as perched aquifers. The Big Swamp Wetland is one example of this morphemic process. In 2014 this swamp was referred to as possibly sitting over a perched aquifer. By 2017 this aquifer is referred to as an alluvial aquifer. And if the Victorian Government definition of a perched water table is applied, then the alluvial aquifers as referred to in the Jacob' reports would qualify as a perched water table. "***perched water table – means an aquifer that occurs above the regional water table, in the unsaturated zone. This occurs when there is an impermeable layer of rock or sediment or relatively impermeable layer above the main water table/aquifer but below the surface of the land.***"[15]

Gathering together the historical and present day data clearly shows that upstream of the Big Swamp Wetlands was a natural discharge point of groundwater due to the effect of upward hydraulic influence from the Lower Tertiary Aquifers. There is every indication that the swamp itself was a discharge point for the LTAs as well. An observation bore drilled into the LTA underneath the Big Swamp Wetland pre groundwater extraction, would have squirted water metres into the air above the swamp level (see page **15**). This pressure would have been doing four things.

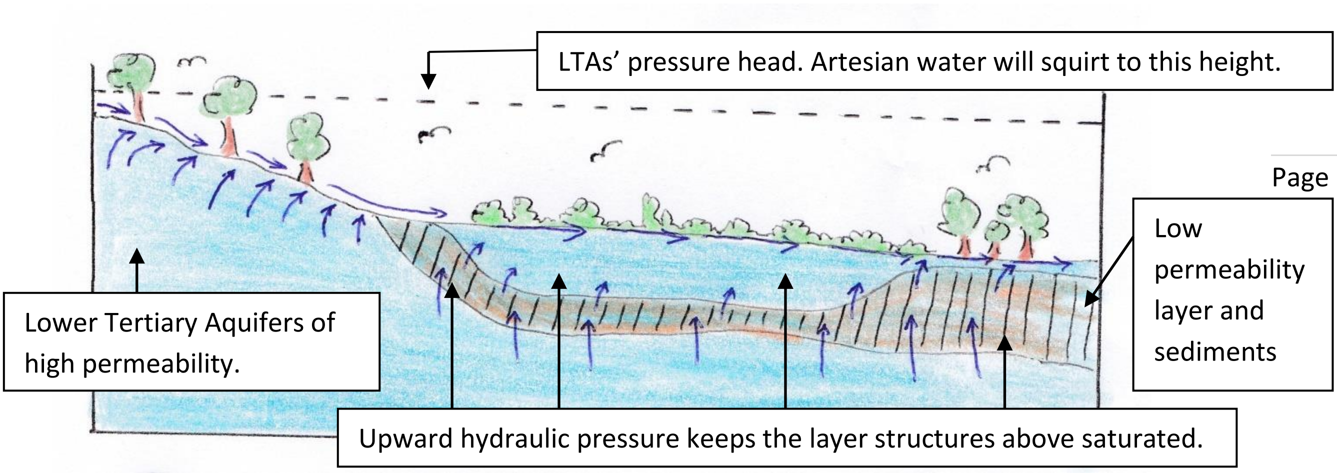
1. Maintain an overflow discharging from the LTA through springs, creeks and rivers.
2. Keeping any hydrogeological unit (alluvial aquifer/aquitard/perched aquifer) in Boundary Creek and the Big Swamp Wetland region, saturated by way of an upward vertical leakage/pressure.
3. Preventing the creation of perched and alluvial aquifers and the drying out of ground water dependent wetlands.
4. Buffering any impact on springs and creeks from drought and climate change.

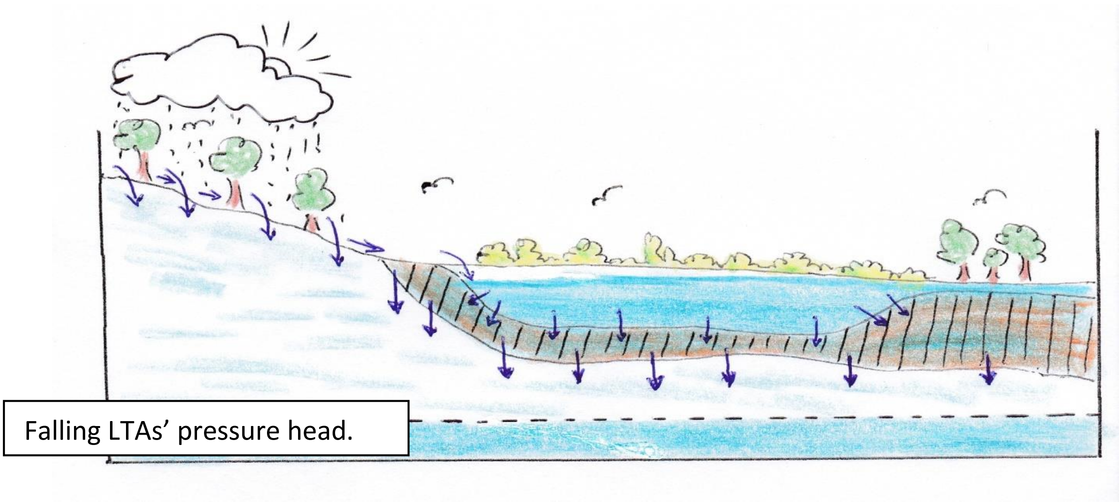
The creation of alluvial aquifer water tables as a result of groundwater extraction is best described through statements made in the SKM, Barwon Downs Flora Study, 2009.[16]

“***The aquifer pumped by the Barwon Downs borefield is known to be heterogeneous in nature i.e. comprises layers of high and low permeability sediments (Dudding 1991) and, as such, has the potential to form perched water tables.***” (see concept illustrations, page **15**)

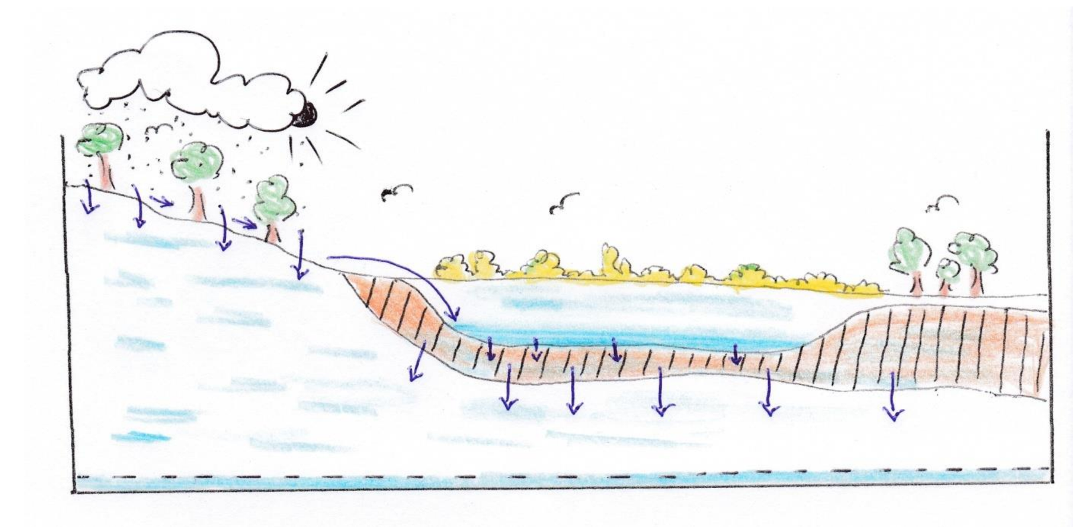
What role the Artificial Supplementary Flows being released out of the Otway to Colac Pipeline play in the creation of perched water tables is not known.
“***It is not known whether leakage of the supplementary flow into the LTA is sufficient to maintain the water table at the surface and keep it connected to the regional water table, or that a perched water table (i.e. disconnected to the regional water table) immediately adjacent to the creek channel has formed.***” It is quite clear that if the LTAs or regional water table is lowered enough, perched and alluvial water tables will become vertically disconnected from the Lower Tertiary Aquifers. However, maintaining the water tables in the LTAs as they were pre pumping, the structural levels including the perched and or alluvial aquifers, would remain saturated. In pre extraction days the artesian pressure head was at a considerable height above these structural formations and would have provided an extraordinary amount of buffering from drought and climate change impact for groundwater dependent ecosystems in the region.

This is an example of what happens removing the buffering capacity as a result of groundwater extraction.





Groundwater extraction lowers the water table pressure head below the low permeable layers, creating a perched water table.



Drawings 1, 2 and 3.

Over time the downward leakage through and from the low permeable layer will cause the groundwater dependent ecosystem to dry out.

Since pumping GDEs such as the Big Swamp Wetlands no longer receive a discharge from the LTAs but become losing systems leaking into the depleted aquifers below. In 2016 "***Available information suggests that Yeodene (Big) Swamp is a groundwater discharge site.***" Jacobs fails to add that this is when the Lower Tertiary Aquifers were in their natural state, not with their water table at 10-15 metres below the wetlands as described in the December 2016 report.(9)

Also, another significant swamp(20) was eliminated from any licence condition consideration in 2004 because it was found by SKM/Jacobs that it sat on a perched aquifer and was deemed not connected to the regional water table. However, in the 2008 vegetation study 4 years later,(16) SKM/Jacobs stated that there was no evidence to support the notion that there were any perched aquifers in the drawdown area of influence. This swamp is within the influence of the Barwon Downs Borefield.

Acid Sulfate Soils.

"***The over-all purpose of the acid sulphate soils program is to establish the approximate extent and associated risks of potential acid sulphate soils occurring within the possible impacts zones, associated with groundwater extraction from the Barwon Downs borefield.***"(8)

Unfortunately the Big Swamp Wetland Actual Acid Sulfate Soil impacts and another farmland impact have not been included in any of the Jacobs' work. It is as though these impacts pre 2014 had not taken place. The start of the Big Swamp Wetland problem began long before the 2014 studies commenced. And consequently the 2015 study report(8) was able to state..."***This assessment makes the assumption that current conditions at the investigated sites are not materially affected from pumping from the borefield.***" A fresh start, with a reference point beginning at 2014.

Otway Water Book 40, titled "*Review of Jacobs 2017 PASS Baseline Assessment,"* is dedicated to examining the Acid Sulfate Soil work conducted by Jacobs, and includes comment on the modelling covered in the Jacobs 14 September 2015 "*Barwon Downs Stage 1 Field Works, Potential Acid Sulphate Soils Field Investigation Report*." Book 40 discusses figures incorrectly labelled; a figure actually referred to but not included and what sense that can be made of other figures presented does not appear to match the drawdown as reported in the Barwon Water yearly reports sent to Southern Rural Water. A discrepancy of 20m residual drawdown is quite substantial. Also it is worth noting that the drawdown in the reports sent to Southern Rural is based on observable data whereas the Jacobs drawdown appears to be based on modelling and estimation. "***The modelling used to estimate the watertable***

drawdown was conducted as part of SKM (2013). In turn this was based on Scenario 2 from SKM (2001)."[8] Unfortunately this is a case of modelling based upon modelling and relies solely on doubtful data put into the model. Modelling Scenario 2 was calculated using an average pumping rate of 4,000 ML/year, whereas during the last drought the actual pumping rate averaged over 11,000 ML/year. To state that "***The model predictions for water table drawdown in the aquitard are based on conservative model assumptions, which include*** (among other things) ***high levels of borefield operation where the pumping is assumed to be an average of 4,000 million litres annually.***"[8] is clearly showing that the data put into the model is not even close to being representative of what actually takes place. As a consequence the model predictions cannot be relied upon.

Even Jacobs throws some doubt on the reliability of this modelling. "***The likelihood of borefield related drawdown has uncertainty in that the estimate relies on modelled results, with associated uncertainty in input parameters and model conceptualisation.***"[8] This admission highlights that the data being fed into the 2017 model[9] has some serious shortcomings.

But when all is said and done Jacobs still believes that the Big Swamp Wetland is a naturally occurring Actual Acid Sulfate Soil (AASS) site. "***The end result is actual acid sulfate soils (ASS). The most well know of these is Yeodene (Big) Swamp...***"[9] Beside the spelling mistake, Jacobs still persist with labelling Actual Acid Sulfate Soils (AASS) as Acid Sulfate Soils (ASS). But, the shame of it all is that it has been proved beyond any shadow of a doubt just after the 30km fish kill down the Barwon River in 2016, that the Big Swamp ***is not*** a naturally occurring Actual Acid Sulfate Soil (AASS) site.[21]

Historical Data Input or Lack Thereof.

So much of the historical data and local knowledge has been discarded, ignored, watered down and or discredited as pertinent. This is evident with the working documents on Stock and Domestic rights, vegetation studies, local input, Actual Acid Sulfate Soil sites, acid water, heavy metal liberation, aquatic studies, fish kills, fire and wetland destruction. Not only have these things been misrepresented the observable data on regional groundwater levels has been basically overlooked and replaced by estimation and modelling outputs. "***This model was used to assess the likely historical impacts on groundwater level and river baseflow of pumping from the Barwon Downs borefield. The model has also been used to generate an estimated groundwater level that would have been seen, if pumping did not occur.***"[9]

An earlier 16 June 2017 Jacobs draft report dealing with "Numeric Model – Calibration and Historical Impacts,"(6) was released in July, seemingly far too early for public comment, because of the most basic of errors contained in the document. This is despite 4 Jacobs staff having prepared the document. Fifty eight incorrectly labelled or missing Figures and Tables were included in the report making it almost impossible to understand. A Barwon Water officer had the same difficulty and asked that Jacobs make corrections. I also asked that the missing Appendixes be included in the revised version. The Appendixes were included with 49 of the corrections completed. The other 9 references to Figures and Tables in the revised version contained the note "***Error! Reference source not found.***"(6) This revised edition had no other readily recognisable changes, which leads into some very lengthy and lively discussion regarding many of the statements and findings quoted. Considering "***The calibrated model was used to determine the historical impact of the borefield, including drawdown and changes to the surface water groundwater interaction at Boundary Creek and other rivers.***"(6) Some time needs to be spent discussing this report.

1. On page 5 in the Executive Summary these two dotted points below certainly raise the blood pressure levels and makes one extremely determined to make it known how wrong these modelling results are.
    - "***The model indicates that the operation of the borefield over the last 30 years is most likely responsible for two thirds reduction of base flows into Boundary Creek. The dry climate experienced during the same period accounts for the remaining third***"(6)
    - "***This suggests that the lower sections of Boundary Creek would likely have no flow periods during summer regardless of groundwater pumping; however pumping has increased the frequency and duration of no flow periods in lower reaches of Boundary Creek.***"(6)

   The overwhelming data, evidence and local knowledge clearly shows that the "***indications***" and "***likelihoods***" of the modelling are wrong.
    - Also, the first decade of this 30 year period was one of the wettest on record not a dry climate experience.
    - During this period not only did Boundary Creek stop flowing to the absolute astonishment of the local fire fighters, the top end of the Big Swamp Wetland had dried out and caught fire with devastating results. The wetland had never been known to be dry pre pumping. It had always been regarded as a reliable source of water for fire fighting.

- Boundary Creek had the first of its no flow days starting just after the drought relief pumping that was carried out by Barwon Water during the 1982-83 drought.
- Rick Evans of SKM quoted this very happening as an example in his 2006 Fellowship study.(10)
- The Shalley family's local history going back to 1912 testifies to Boundary Creek not drying up until after the 1982-83 extraction.
- Data.water.vic.au records confirm this.
- The Day family purchased their Boundary Creek property in the 1970s mainly because Boundary Creek was a continuously and reliable water source, so much so that during the driest of summers irrigation water was a reality.
- In 1986 Farmar-Bowers noted that Boundary Creek was a permanently running stream with little variation over the years and summer seasons.(12)
- Platypus and large species of fish such as blackfish thrived in the stream. Freshwater crayfish were regularly sighted.
- After the 1987-1990s Barwon Downs Borefield stress test pump, Witebsky et al.(11) confirmed that Boundary Creek had been a perennial stream and would remain so if only 1500 ML/year was extracted.
- The large amounts of water extracted under the 12,600ML/year and 20,000ML/year licences far exceeded the sustainable level set down by Witebsky.
- In 1995 the Permissible Annual Volume for extractions was set at 4,000ML/year but was never enforced.
- In 2016 Roger Blake, who has extensive knowledge of the Barwon Downs Borefield development, wrote a paper on behalf of the Winchelsea Landcare Group confirming how wrong the two statements above are.(23)
- Pre groundwater extraction the potentiometric pressure head was many metres above the middle and lower reaches of Boundary Creek, providing such a buffer that this level would never, under natural conditions (including severe drought), fall that low that Boundary creek would stop flowing at the Stream Flow Gauging Station at the Colac to Forrest Road Bridge.

This statement below found on page 77 seems to contradict the two statements above and supports this last dot point. "***At Boundary Creek the drawdown in the LTA has caused the creek to change from being a***

gaining creek (groundwater provides baseflow) to being a losing creek (water flows from the creek to the groundwater)."[6]

2. The figure reproduced below (see page 21) is found on page 36 of Jacobs' 18 June 2017 report.[6] The major extraction in 1982-83 does not appear on it. Neither is the source of the rainfall data stated. The 1982-83 drought extractions supposedly supplied 50% of Geelong's water supply, making the 1982-83 extraction notable and should have been included on the hydrograph.

   No explanation is given explaining what is happening where I have placed a dotted red oval around the last section of the figure. The hydrograph continued to drop quite severely taking some considerable time to start responding to the cessation of pumping and increased rainfall. This is markedly different and unlike the earlier behaviour as depicted in the graph. Rainfall and drawdown are not closely correlated.

   "***Groundwater level fluctuations in Bore 109130 appear to be influenced by the combine effect of below average rainfall and groundwater pumping from Barwon Downs borefield. Groundwater levels declined significantly during the late 1980s in response to pumping, in contrast to average rainfall conditions.***"[6] The graph appears to indicate the opposite to this. As the rainfall increases the water table drops. This period was also when the stress test pump was conducted. The results indicated that with an extraction in excess of the 1500ML/year the buffering and mitigating capacity of the LTAquifers at surface level will be negated. The aquifer will then enter a mining stage. The above quote continues with "***Groundwater levels recovered when pumping ceased and then declined again, this time more significantly, in response to the combined influence of the Millennium Drought and pumping from Barwon Downs. Groundwater levels again recovered after pumping ceased in 2003 and rainfall conditions returned to average. However the groundwater levels did not reach pre-pumping levels before declining again in response to less rainfall and pumping. In recent times, groundwater levels have risen, as the aquifer recovers.***"[6]

   What is not told is the fact that groundwater levels in adjoining aquifers of the Otway Ranges and Western District have not undergone the roller coaster ride like the levels under the influence of the Barwon Downs Borefield. (See pages 21-22)

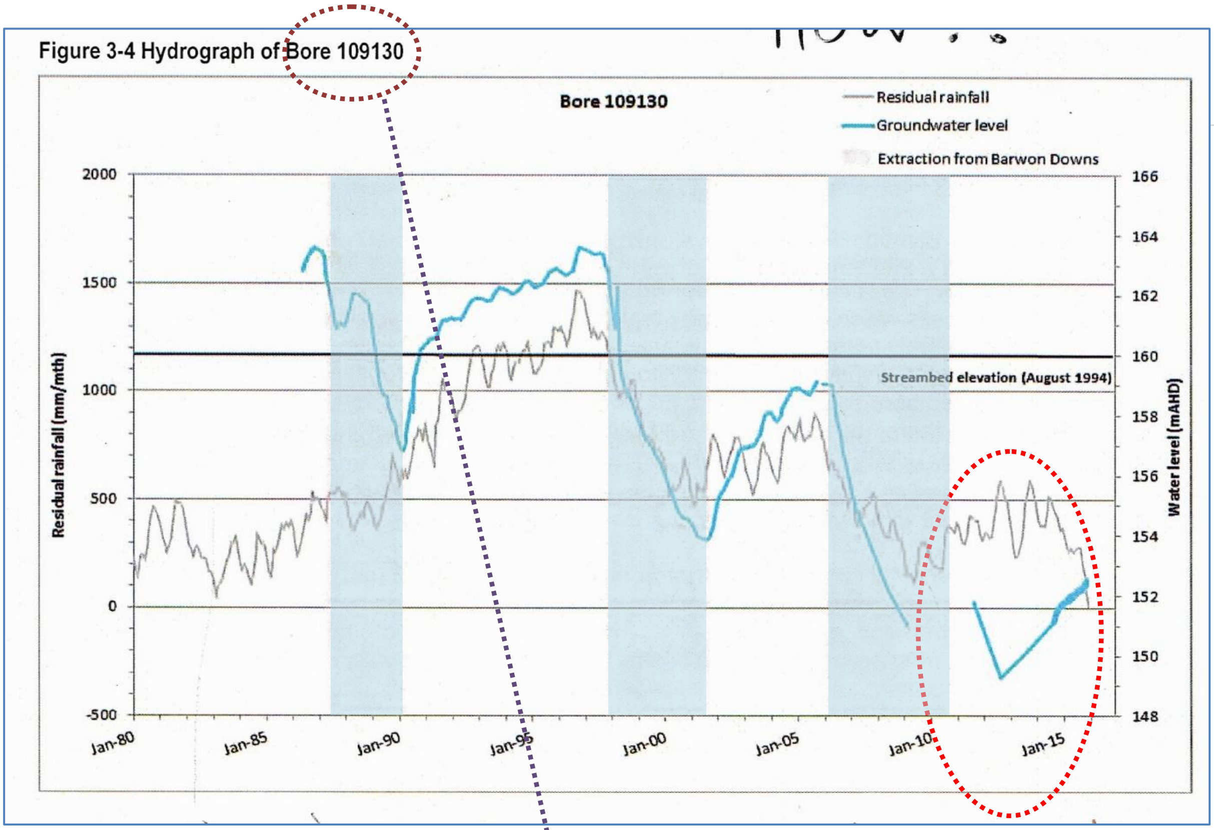
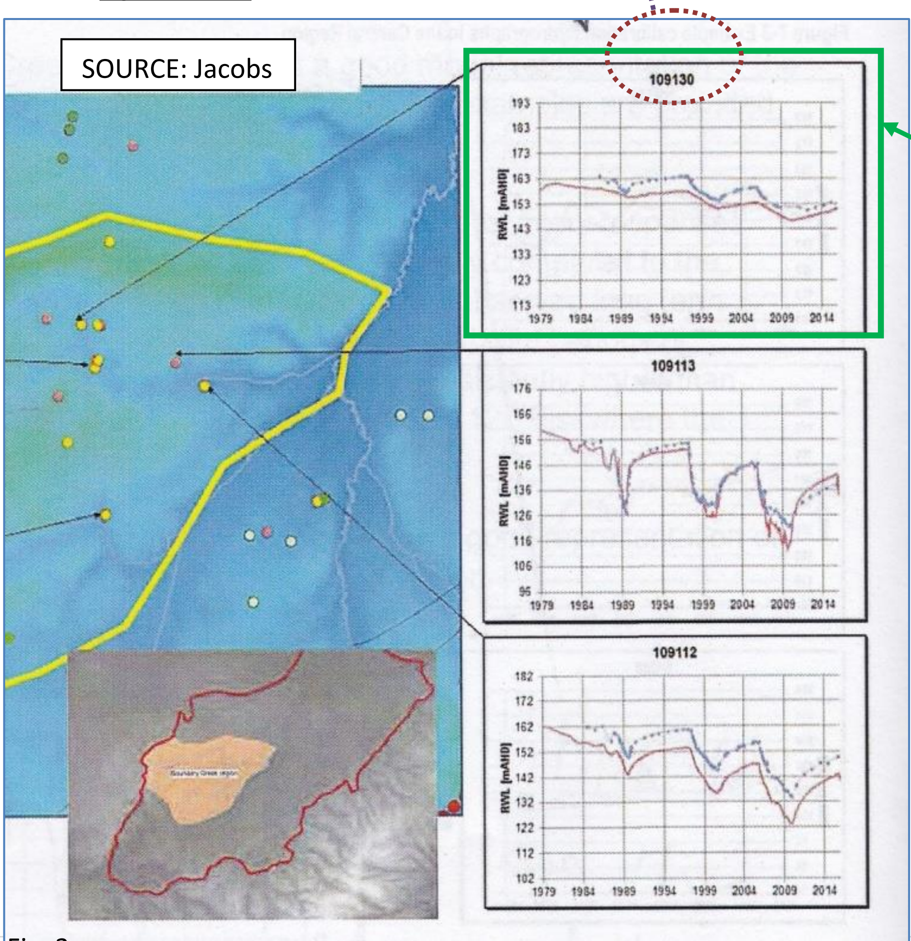


Fig. 2 SOURCE: Jacobs



This part of a figure is copied from page 63 of the Jacobs' report(6) depicting another way to view the rise and fall in observation bore 109130. This figure has been used as part of the explanation for what has been taking place in the Boundary

Fig. 3

Creek Catchment. The hydrographs shown in Figs. 2&3 for the same observation bore 109130 "paint" two very different stories. Fig. 3 depicts 109130 as almost flat.

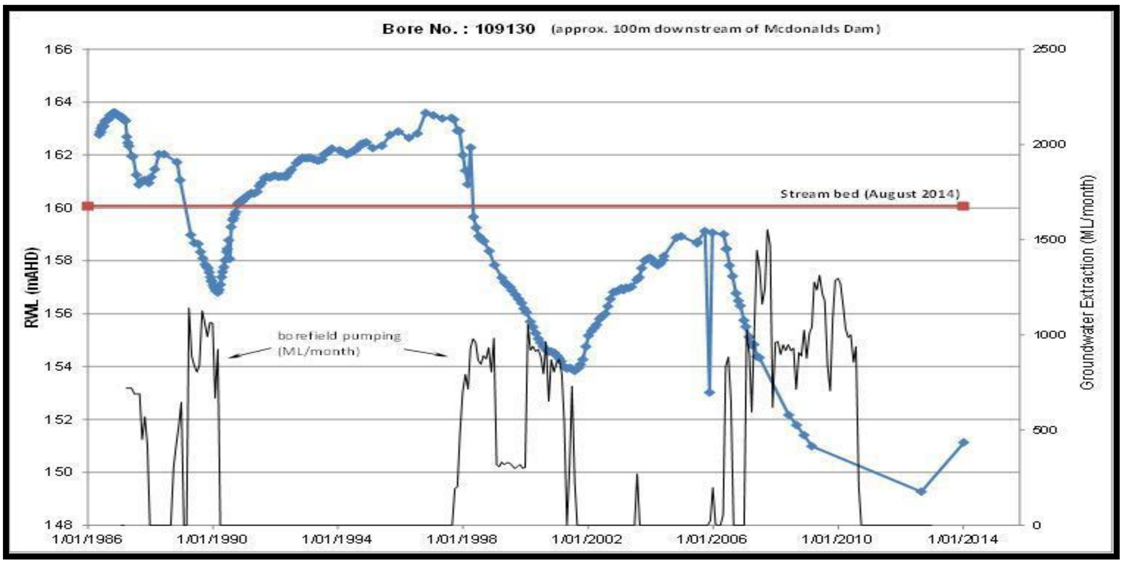


Fig. 4 **Source. R. Evans presentation to Barwon Downs Groundwater Community Reference Group 2015.**

Fig. 4 is also a hydrograph of observation bore 109130 and includes the monthly extractions of groundwater. The extractions show a much better correlation in relation to the drawdown than the figure showing the relationship between drawdown and residual rainfall. The pumping causes the water tables to drop, whereas the rainfall lows simply indicate the reason why there was a need to conduct groundwater extractions.

In a similar fashion a false impression is given in the water table oscillations in the Kawarren/Gellibrand region. "***The potential for impacts where the aquifer outcrops in the Gellibrand catchment, in particular Ten Mile Creek and Yahoo Creek, was also considered. Drawdown mapping indicates that drawdown in these areas in 2012 (a time period of approximately maximum historical impact from the borefield) is less than 1 metre.***"(5) Jacobs' graph presentations shown on page **23** (Fig. 5), gives the impression that impacts have been minor. However, when compared with the Southern Rural Water data (Figs. 6 & 7) a significant difference is noted. The one metre drawdown stated above, becomes closer to 4-5 metres.

A 2015 Jacobs' report(5) states..."***The purpose of the study was not to determine the magnitude of impacts of the Barwon Downs borefield on the Gellibrand groundwater system.***" It also states that "***While these assessments indicate that any noticeable impacts are unlikiely, a more detailed assessment of these impacts will be made once the computer model has been updated and calibrated.***"(5) The updated model Groundwater Model Predictive

Scenarios Report[9] December 2017, predicts that drawdown for Ten Mile Creek, Loves Creek and Yahoo Creek will be minor, and in the order of less than 0.1 m. The hydrographs in the **blue** and **green** circles certainly give this impression.

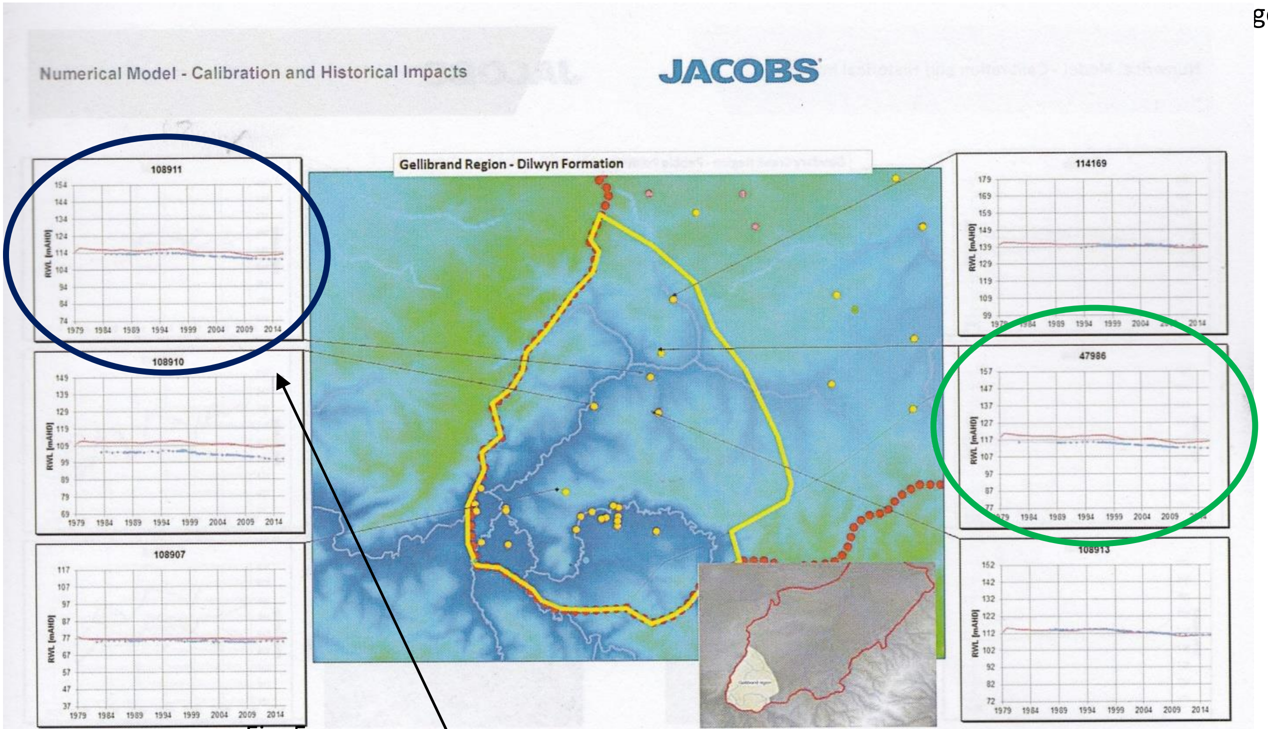
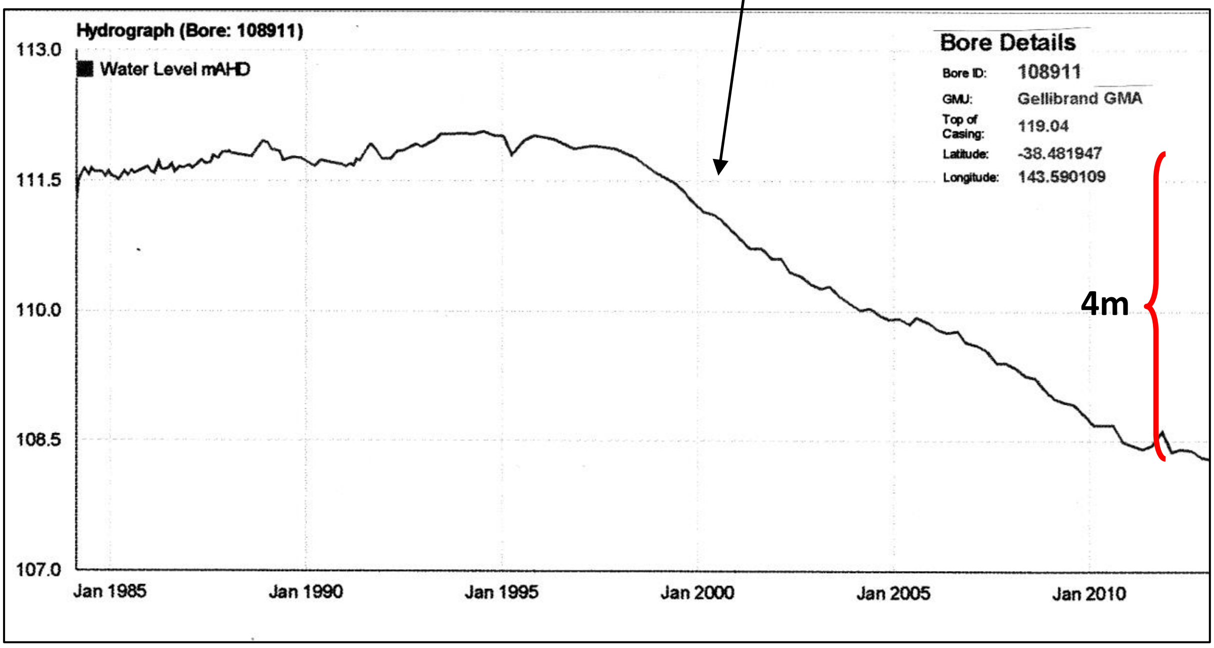


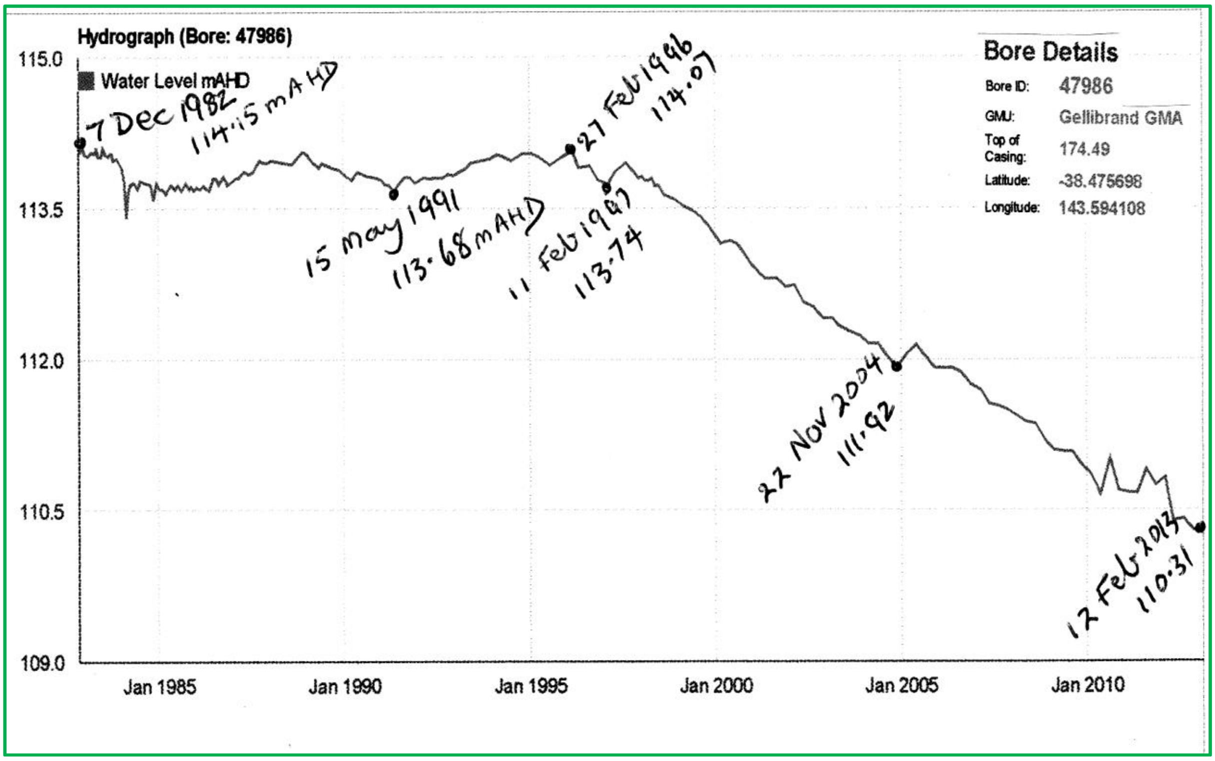
Fig. 5

However, the hydrograph in the **blue circle** (observation bore 108911) looks markedly different to the one found for the same bore on the Southern Rural Water site.



<u>Fig. 6 SOURCE</u>: Southern Rural Water.

The hydrograph in the **green circle** (observation bore 47986) is also markedly different to this same bore located on the Southern Rural Water web site.

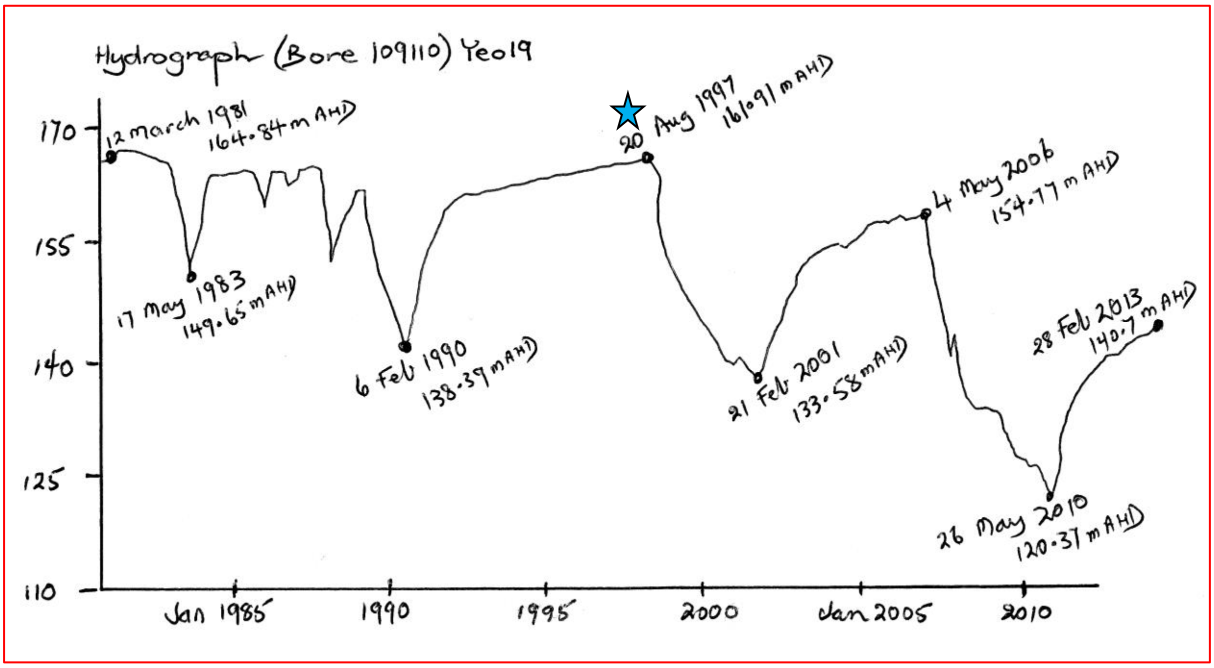


<u>Fig. 7 SOURCE</u>: Southern Rural Water.

The impression given in the Jacobs report[6] is that the watertables in observation bores 109130, 108911 and 47986 are relatively flat; have not altered that very much and appear to be relatively unchanged over time. The Southern Rural Water data for the same bores show that there has been an ~4 m fall and have continued to fall despite pumping having ceased in 2010. The fact that there have been wet winters since 2010 and little recovery in these bore, indicates that the impact from the Barwon Downs Borefield has reached this area and is drawing water away from the flowpath that used to naturally recharge these bores. The water tables shown for bores down the Kawarren and Gellibrand groundwater flowpaths are neither flat nor unaffected. The cone of depression created under the Kawarren township being another example of this impact.[19]

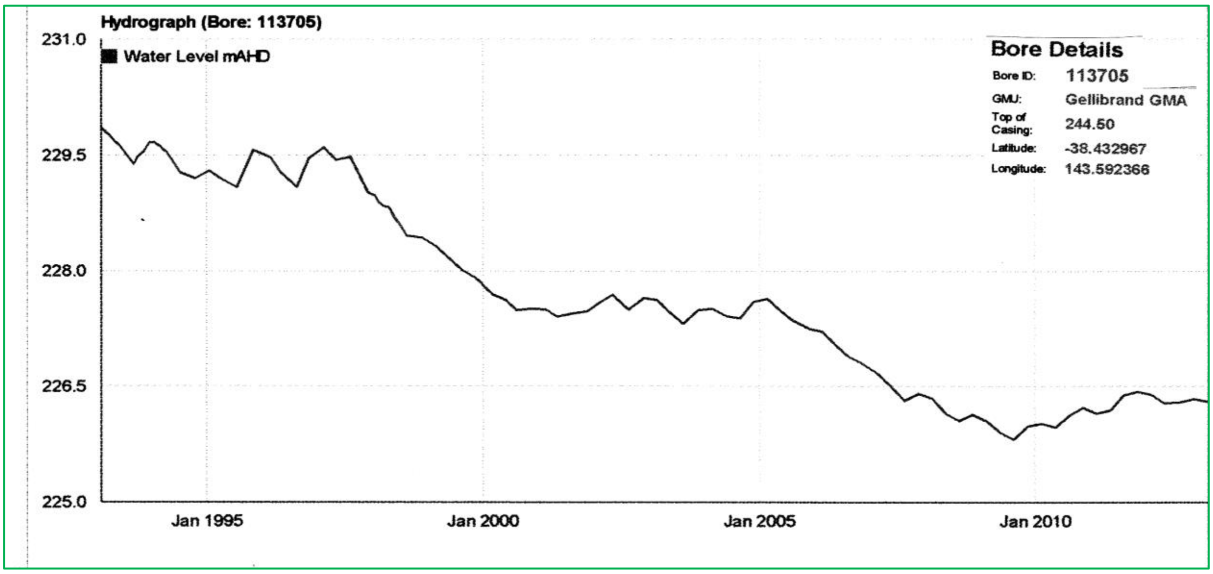
The following hydrographs on page **25** below is another example showing the difference between the drawdown on a bore within close proximity to the Barwon Downs Borefield and its influence, and one further removed in the Gellibrand River Catchment.

The falls in this hydrograph for bore 109110 (Fig. 8) neatly follow the groundwater extraction periods. Bore 109110 is in the Barwon Downs Catchment and has dropped ~44 metres at its lowest period.



<u>Fig. 8 SOURCE</u>: Southern Rural Water.

Bore 113705 from the Gellibrand region (Figs. 9&10) shows a gradual decline of ~4metres with minimum recovery after pumping ceased in 2010, despite several wet winters following the cessation of pumping.



<u>Fig. 9 SOURCE</u>: Southern Rural Water.

Using the same scale as has been used in Fig. 8, the Gellibrand graph (Fig. 9) then appears flat, and the drawdown seemingly of little consequence (Fig. 10).

<u>Fig. 10 SOURCE</u>: Southern Rural Water.

However, a 4-5m drawdown is critical considering the naturally low summer flows in spring discharge and flows into the creeks and river of the Gellibrand River Catchment. The buffering capacity of the Lower Tertiary Aquifers is dramatically curtailed when the falls in the watertable drop 4-5 metres.

Is a 40 metre Drop in Hydrographs reasonable?
The further away from the influence of the Barwon Downs Borefield and *even taking into account the Millennium Drought period*, the less the impact has been on the regional groundwater levels. For example the northern part of the Newlingrook Aquifer system has experienced a 20cm oscillation of it water table levels. Further to the south in the Southern Newlingrook Aquifer system the oscillation is unnoticeable.(13) To the west, irrigation and urban western district town extractions have been found to cause a 10cm/year lowering of the regional aquifer water tables.(14)

Zero; 20cm oscillation; 10cm/yearly drop and 4-5 metre drop in the Gellibrand River Catchment is nothing when compared with a 40 metre plus drop in the regional water table levels as experienced in the Barwon Downs Borefield area of influence.

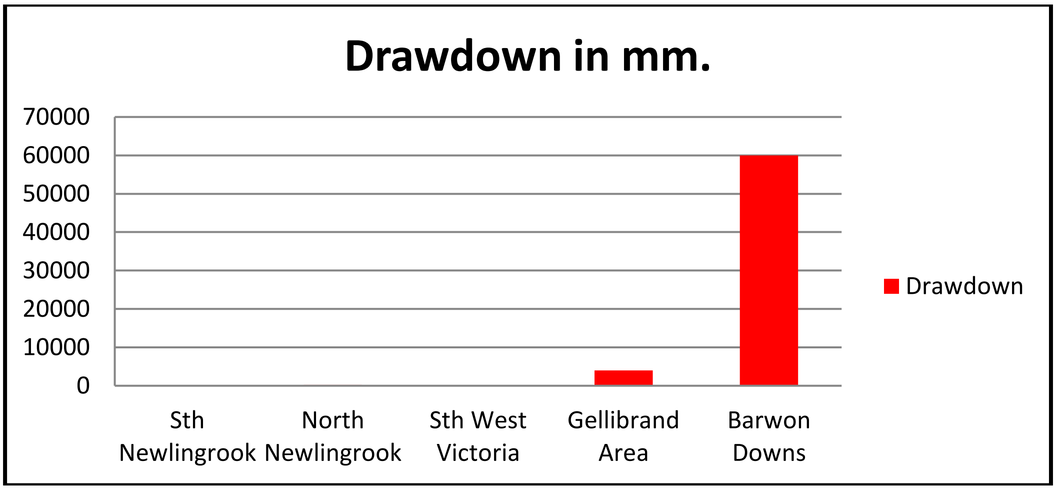


Fig. 11

This pattern of drawdown is telling in that:

- The Millennium Drought, supposedly one of the worst droughts on record, had little immediate impact on the ability of an untapped aquifer system (Southern Newlingrook) to buffer such a severe drought.
- A 40 metre LTA water table drop in the Barwon Downs area dried up springs, devastated groundwater dependent ecosystems and dried up at least one perennial creek.

- In 1994 it was "***...anticipated that large scale extraction in the Gellbrand/Kawarren region will have an influence on flow, in particular Yahoo and Tern Mile Creeks, similar to the effects noted at Boundary Creek due to pumping at the Barwon Downs wellfield.***"[22]
- A 4-5 metre drawdown in the Kawarren/Gellibrand area from the Barwon Downs Borefield has placed a catastrophic cloud over the Loves Creek catchment going the same way as the Boundary Creek Catchment, especially when it is known that the extremities of the area of drawdown influence from the Barwon Downs Borefield is expanding and is the slowest to recover.

  "***...at distance from the borefield in outcrop areas, groundwater levels in 2012 were lower than in 2010 due to the continued expansion of the drawdown cone at large distances from the borefield after cessation of pumping.***"[6]

  "***Typical of an aquifer recovery, the rate of recovery is slower further away from the borefield.***"[9]
- "***An investigation by Jacobs (2016a) confirmed that the drawdown extends to Kawarren.***"[6] The cone of depression under the township area of Kawarren,[19] and the 4-5m drawdown, strongly suggest that as the cone of depression from the Barwon Downs Borefield spreads, so will the impact at Kawarren be similar to the disastrous impacts witnessed along the Boundary Creek catchment. There will be no need to pump at Kawarren to fulfil the disastrous predictions made in 1994.

Aquitard Leakage.

In the Witebsky et al.[11] report summing up the results of the stress test pump at the Barwon Downs Borefield between 1987and 1990, it predicted that a major supply of recharge to any depletion in the regional groundwater caused by the Barwon Downs Borefield, would come from vertical leakage downwards out of the Narrawaturk Marl aquitard.

"...*Leakage from the overlaying marls is likely to be the major source of recharge under stressed conditions.*"[11]

Vertical Leakage can be in an upwards or downwards direction. Water can be forced up from one layer to another. For example when the aquifers in the LTA are under pressure they force water up into the Narrawaturk Marl above.

Lower the pressure in the LTA and the water in the Narrawaturk Marl aquitard will begin to leak down in an attempt to fill the depleted LTAquifers below.

Leonard[17] was discussing the certainty of vertical leakage in this very area as far back as 1984. The Witebsky et al.[11] report also contained this... "***The immediately overlaying Narrawaturk Marl is up to 170m in thickness and grades from silty sands to marl. It has very high storage capacity and within the borefield area is known to contain groundwater of good quality. Under undisturbed conditions an upward vertical, hydraulic gradient exists between the marl and the Lower Tertiary aquifer system and the marl is recharged with groundwater of good quality from below.***" Under undisturbed conditions the leakage is upwards.

In 2016 Jacobs[18] stated that when an upward hydraulic gradient exists "***This facilitates upward leakage from the aquifers into the overlaying aquitard and is a key discharge process for the aquifer.***" The same Jacobs report[18] has this to say "***...groundwater levels in the LTA have fallen below the overlaying MTD for periods of time.***" The MTD being the overlaying aquitard, the Narrawarturk Marl. Once this happens the marl begins to leak downwards.

Page 31 of the SKM Report 2009[16] also discusses the possibility of vertical leakage and states that at this stage there is no evidence that this has occurred. The reason for this lack of evidence is that only 3 of the 61 regional observation bores used in Report 2009 were monitoring this possibility. The principle of vertical leakage has been a reality for decades and it seems unbelievable that scant data has been collected over the 34 year period of groundwater pumping at Barwon Downs, especially when it was stated in 1995 that vertical leakage into the depleted aquifer would be a major source of recharge. Just because data does not exist doesn't automatically rule out that vertical leakage is taking place. It is doubtful that these considerations have been factored into the 2017 model.

Artificial Supplementary Flows.

The regular release of the Artificial Supplementary Flows into the Barwon Downs Borefield area of influence, do not appear to have been factored into the 2016-2017 modelling exercise.[9] The influence these releases have on the data collected should be taken into account.

There are 5 references made to the supplementary flows in the December 2017 predictive modelling report. Four of them referr to maintaining the flows and the other reference states that it is likely that the supplementary flows are sustaining the vegetation in the location upstream of the Big Swamp Wetlands.

Salt Intrusion.
At no stage in any of the Jacobs studies has there been any mention of salt intrusion from either sea water or salt laden layers above the Lower Tertiary Aquifers. The study and or risks inherent to changing groundwater flowpaths altering movement of salt, should have been investigated. Geological structures above the LTAs in the Barwon Downs region are known to contain significant amounts of salt laden material. When disrupting the natural functions of groundwater behaviour it is reasonable to assume that the way in which salt fits into these changed functions will have a significant influence. If not in the short term, then in the long term. Little to nothing is being done to monitor any change. In fact, nothing has been done to study where the salt layers, structures and flowpaths fit into the overall conceptual model.

Pumping Scenarios.
During the four major pumping extractions at the Barwon Downs Borefield more water was pumped than the highest of the 4,000 ML/year extraction scenarios fed into the December 2017 model. The Millennium Drought saw a yearly average of ~ 11,000 ML extracted. There has been no explanation why pumping scenarios at these higher levels have not been conducted.

Only a Small Section of the Gellibrand River Modelled.
In August 2015 Jacobs was concerned that the current model was only covering a very small section of the Gellibrand River. "***This raises an important point regarding the domain of the current numerical model, which only includes a small part of the upper Gellibrand River, and is hence not capable of determining these impacts.***"(5) This same report states that "***...further the current computer model does calibrate well in this area (this means that the computer model results do match well with the observed groundwater behaviour in this part of the model).***"

Also, "***Boundaries are important because they can potentially control the extent of drawdown caused by groundwater pumping and they also control how the model allows water into or out of the system, which can significantly affect the behaviour of the computer model.***"(5)

"***The south west boundary is important because the definition of this area will influence the extent to which potential impacts from the groundwater pumping extend into the Gellibrand catchment.***"[(5)] Up to August 2015 the modelling of the time covered a very small section of the Gellibrand River and at an extremity of the model boundary. The results of the modelling for this area were of considerable doubt. The model required "revamping" in order to gain better results. Unfortunately, no mention of how the model has been updated or modified to take into consideration the above points, can be found in subsequent reports.

Loves Creek Surface Water Losses.
"***Love Creek loses streamflow to groundwater for the majority of the year and becomes a gaining creek for a short period during the wet months of the year.***[(9)] There are at least three concerns with this statement. Firstly how has it been calculated that Loves Creek is a losing creek, and secondly why is it losing surface flows? Where does the water loss go?

It is difficult to understand what is happening here if a clear explanation is not given to these questions. To further confound what is being stated by Jacobs, there is only one stream flow gauging station in the middle section of Loves Creek. How the stream has been calculated to be losing must be explained. A bore, Number 108910, in close proximity to this station shows a substantial upward hydraulic gradient many metres higher than the stream bed. This would indicate there is an extremely high likelihood that Loves Creek could be a gaining stream in sections. It also throws some confusion as to where the water could possibly be going if as stated by Jacobs, it is a losing stream for the majority of the year.

Comment on the Amount of Critical Analysis.
It is truly commendable that Tracey Slatter, Managing Director of Barwon Water, has opened the channels of transparency, making any document asked for available and or accessible. But this does not necessarily mean that the documents are critically reviewed and or accepted by the general public and given a social licence to proceed with groundwater extraction at the Barwon Downs Borefield. Whether the general public are educated in the nuances of groundwater is a totally different story and can best be highlighted with the example quoted on page **17** of this book. The fact that this Jacobs' report was placed on the Barwon Water website "Have your say," in June 2017 and not one query has been made to Barwon Water regarding any aspect of this report

including the 58 incorrectly labelled Figures and Tables, indicates how difficult it is to

- have the general public not blindly accept reports,
- to inform the public,
- to get the general public to read material,
- for them to be critical of what is presented, and
- not accept something that on first reading gives the impression of being reasonable and correct.

In summary there has to be a great deal more done to inform the public other than providing the public with consultants' reports, especially when these reports have the deficiencies as listed on pages **4**-**6**.

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