

OTWAY WATER

BOOK 30

Page |

“Sick of Hearing That.”



July 2015
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In the late 1990s after comprehensive investigations and based on sound scientific data, a Permissible Annual Volume (PAV)⁽¹⁹⁾⁽⁷¹⁾⁽⁸⁰⁾ of 4,000 ML was recommended and accepted for the Gerangamete Groundwater Management Area. This meant that there was to be no more than 4,000 ML of groundwater extracted from this Management Area. This Management Area included the Barwon Downs Borefield.

However, one month before this PAV was adopted in October 1997, Barwon Water began to extract groundwater from the Barwon Down Borefield.⁽³⁵⁾⁽³⁷⁾

A 12,600 ML/year groundwater extraction licence⁽⁵⁷⁾ had been granted to Barwon Water two years earlier, and in September 1997 Barwon Water decided to start exercising this two year old right.⁽³⁵⁾

The 12,600 ML/year licence was due for renewal in 2002 and despite the 4,000 ML/year PAV Southern Rural Water made the decision to allow Barwon Water to continue with the 12,600 licence. Southern Rural Water decided that the 4,000 ML extraction limits would be taken into consideration when the licence was being reviewed in 2002.⁽³⁷⁾

By the time the renewal process had been completed in 2004 the Permissible Annual Volume had been changed to a Permissible Consumptive Volume whereby the 4,000 ML could be averaged out over a given number of years. In 2004 Barwon Water was granted an extraction licence of 20,000 ML/year, with no more than 80,000 over 10 years and no more than 400,000 ML over 100 years.⁽⁴⁵⁾

Between 1986 and 2012 and after extensive studies Barwon Water decided, rightly or wrongly, to make a “fresh start” in 2012.⁽⁸⁾

When developing this 2012 expanded monitoring program for the Barwon Downs Borefield the program documentation contained this quote...

“Potential risks to the environment were identified, and, as a result, conditions in the licence (2004 licence) were put in place to mitigate any unacceptable impacts known at the time.” (Taken from the 2012 SKM, Ecology Australia and La-Trobe University report prepared for Barwon Water⁽⁸⁾)

The 2012 version was modified and after the 2013 version had been finalised, Barwon Water selected and set up the Barwon Water Groundwater Community Reference Group to oversee the implementation of the program. The first meeting of this Reference Group took place in October 2013. I was selected as one of the members of this Reference Group.

Many meetings took place in the early stages of this Reference Group and by 25 March 2014 I was a little tired of three reoccurring things.

1. The lack of gaining anything but a scant recognition of past experience, data and reports relating to the Barwon Downs Borefield operation pre 2012.
2. Most referrals to past reports were put aside because the issuing of the 2004 extraction licence was stated as being based on the best information at the time, and
3. What was done before is past history and a fresh start was needed.

After the 25 March 2014 meeting I had had enough of the put downs and the difficulties encountered attempting to put forward early study findings. The trigger this night was the repeated statement that the 2004 licence was granted taking into consideration and catering for all the known risks at the time. This prompted sending an email to ALL participants of the Barwon Downs Groundwater Community Reference Group.

Following is an unabridged copy of the 20 points made.

1. *The PAV (Permissible Annual Volume) to be extracted had been recommended in 1995 and accepted in 1999 at 4000 ML/year. The licence issued in 2004 allowed 20 000 ML/year extraction.* ⁽³⁷⁾
2. *Any extraction over 4000 ML/year to included artificial recharge. No provisions made.* ⁽⁷⁹⁾
3. *Vertical leakage from layers above the EVF were determined by SKM as a major recharge of the aquifers being pumped from. No provisions were made to measure the impacts this may cause. Vertical leakage data collection recommendations had been made on numerous occasions – no conditions evident in the licence.*
4. *To best understand the connectivity between aquifers and recharge processes relating to salinity studies, SKM in 1995, was recommending nested bores as best practice.* ⁽⁶⁰⁾ *SKM states that nested bore hydrographs are better at revealing connectivity between shallow and deep water aquifers much better than single bores in a location. This was not reflected in the licence conditions.*
5. *Boundary Creek had run dry on numerous occasions coupled with,*
6. *the fact that SKM had determined the critical level when this would happen was when the water table level in Yeo 40 dropped below 158 mAHD. The licence did reflect this with a trigger level of 158.5 mAHD in Yeo 40 requiring the release of supplementary flows down Boundary Creek. Unfortunately, the licence conditions did not take into account a review condition if this was unsuccessful. Boundary Creek had dried up on numerous occasions and local community experience had concerns over the length of time the creek took to begin flowing after substantial rainfall. No*

condition applied to the licence to investigate this or revise the mitigation proposals until the licence was to be reviewed fifteen years later in 2019. The success of the supplementary flow regime has been abysmal.

7. The Upper Barwon Landcare Group warned of numerous other creeks being affected.⁽⁴⁴⁾ No provision was made in the licence to study these.

8. The top end of the Big Swamp had dried out and caught fire. Only possible when the water table dropped below 158 AHD.⁽⁵⁷⁾ Information at the time coupled with the creek running dry, indicated and had shown that something was seriously wrong upstream of the Stream Flow Gauging Station on Boundary Creek.⁽²⁵⁾ No provision was made to seek the cause of this dilemma.

9. The acid level readings in Boundary Creek had dropped dramatically and were reflected in the water testing at the Stream Flow Gauging Station.⁽²⁵⁾ This risk/happening was ignored and consequently no provision was made in the licence conditions.

10. Boundary Creek would cease flowing over the summer period unless there was substantial rainfall.⁽²⁵⁾ The cause of this was not to be investigated and so provide a basis for better protection and provision of mitigating measures to prevent unacceptable impacts.

11. Even when Boundary Creek commenced flowing the water was not palatable to cattle until there had been considerable flushing flow through the system. Some recognition of this was reflected in the licence conditions and resulted in supplementary water being released from the Otway to Colac Pipeline into Boundary Creek.⁽⁴⁵⁾ Best practice at the time would have included a review process of the suitability and success of this arrangement.

12. The peat in the Big Swamp caught fire in 1997 and again in 1998. This was identified as a risk and ignored.

13. Platypus and large fish were decimated especially in the lower reaches of Boundary Creek. This was not acknowledged or recognised and therefore no provision was made.

14. Control plots for a flora review process due in 2009 were chosen at locations inside the drawdown influence. Best practice for selection of control plots ignored.⁽⁵⁵⁾

15. The 1990 flora, fauna and fish study results conducted by Barwon Water were flawed from the outset. (1988 Tunbridge⁽⁶⁵⁾ fish study overlooked. Nellie Shalley local community experience and knowledge ignored.⁽³⁹⁾ Belcher and other researchers unaware of previous pumping history.⁽⁹⁾⁽¹⁰⁾) These and the follow up studies in the early 2000s were based on doubtful 1990 results. Best practice not employed and as a result licence conditions unable to reflect appropriate conditions.

16. Local community members on the review committee at the time, wanted a 5 year licence review. No provision made and at the time was seen as best practice but was also seen as unacceptable to Barwon Water in regard to

infrastructure expense required for such a short period. Best practice compromised.

17. The SEPP for groundwater (S 107, 1997) best practice was not reflected in the licence conditions.

18. The SEPP for surface water (S 160, 2003) was also not reflected in the licence conditions. The principles including precautionary, accountability, intergenerational equity, conservation of biological diversity appeared to be given scant recognition.

a. Warnings that many of these principles should be taken notice of came in the form of discussions and recommendations from Smith,⁽⁶¹⁾⁽⁶²⁾ Stanley,⁽⁶⁴⁾ Farmar-Bowers⁽³¹⁾, Witebsky,⁽⁷⁹⁾ Nellie Shalley,^(pers.com) Doug Chant,^(pers.com) the CCMA, the Upper Barwon Landcare Network⁽⁴⁴⁾ and the Gerangamete Flats Landcare Group.

The provision of environmental flows as outlined in this SEPP was largely ignored, if in fact it was even referred to. The licence contained no environmental flow component.

19. Best practice local water management expertise and knowledge largely ignored.

20. Data collection and benchmarking pre 1991 largely ignored.⁽⁸⁾

The list should have been longer and on reflection it most definitely should have included the fact that Barwon Water had failed to implement the majority of recommendations made in studies dating back to 1986 (see page **12** and **13**). Not implementing these recommendations and therefore having less data for analysis, has been one of the major arguments put forward by Barwon Water arguing that not enough is known, and a new start should be made from no earlier than 2012. It is interesting to note that many of the 1986, and follow up recommendations, form part of the latest expanded monitoring program of 2013.

Despite Barwon Water's justification for a fresh start in 2013 there is sufficient research, data and anecdotal evidence to support the argument that there is enough known to reach definitive answers regarding impact issues created by urban groundwater extraction at the Barwon Downs Borefield.

As well as the scant regard taken of earlier research a major concern with the 2013 program is the lack of scientific vigour being applied to the implementation of this program (see Otway Water Book 31 currently being written).

Additional Indicators that Should Have Been Addressed When Identified.

(These things have not been covered in any detail if at all in earlier Otway Water.)

A. In 2002 as part of the groundwater extraction licence for the Barwon Downs Borefield, Barwon Water commissioned SKM to conduct several studies. The one dealing with impacts on Boundary Creek contained these two statements.

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1. *“The baseflow component generally does not respond rapidly to rainfall and often represents a relatively stable and constant streamflow component.”*
2. *“It has been noted that during periods of significant pumping from the aquifer, the flow in Boundary Creek is reduced and in some instances it has ceased flowing altogether.”*

One of the draft licence conditions contained this statement.

- *“Groundwater extraction at the borefield reduces groundwater levels beneath Boundary Creek such that groundwater discharge ceases and the creek stops flowing in summer.”* (see Appendix One, page 15).

Another draft licence condition contained this statement.

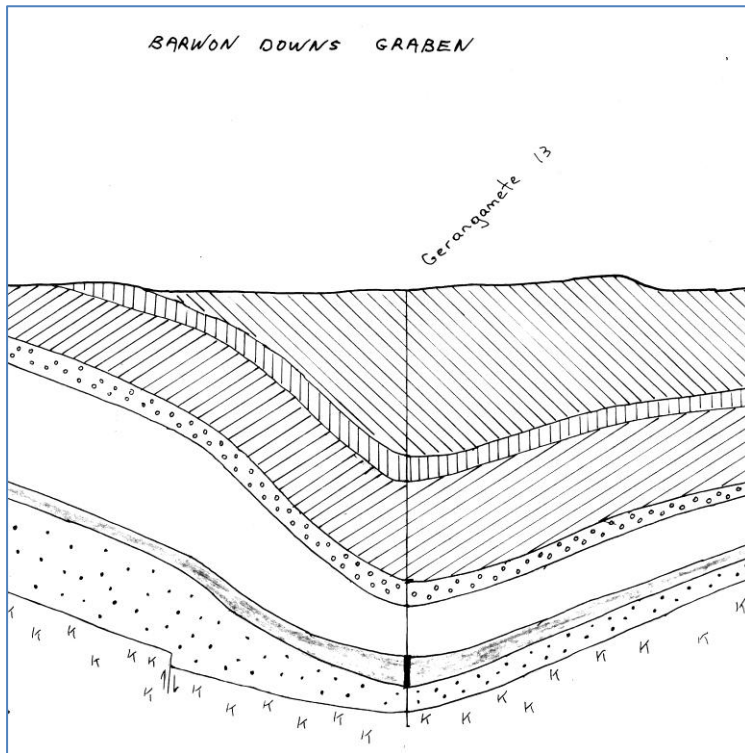
- *“Declining water levels below Boundary creek due to pumping result in a lowered water table beneath vegetation adjacent to the creek.”* (see Appendix Two, page 16).

What these statements were clearly saying was that the impact in the unconfined area of the Eastern View Formation (including the Dilwyn, Mepunga and Pebble Point Aquifer Formations) was relatively well accepted. What was not known was what was taking place in the various layers of the earth crust above where the actual borefield was extracting water. These layers included the Gellibrand Marl, the Narrawarturk Marl and the Clifton Formation.

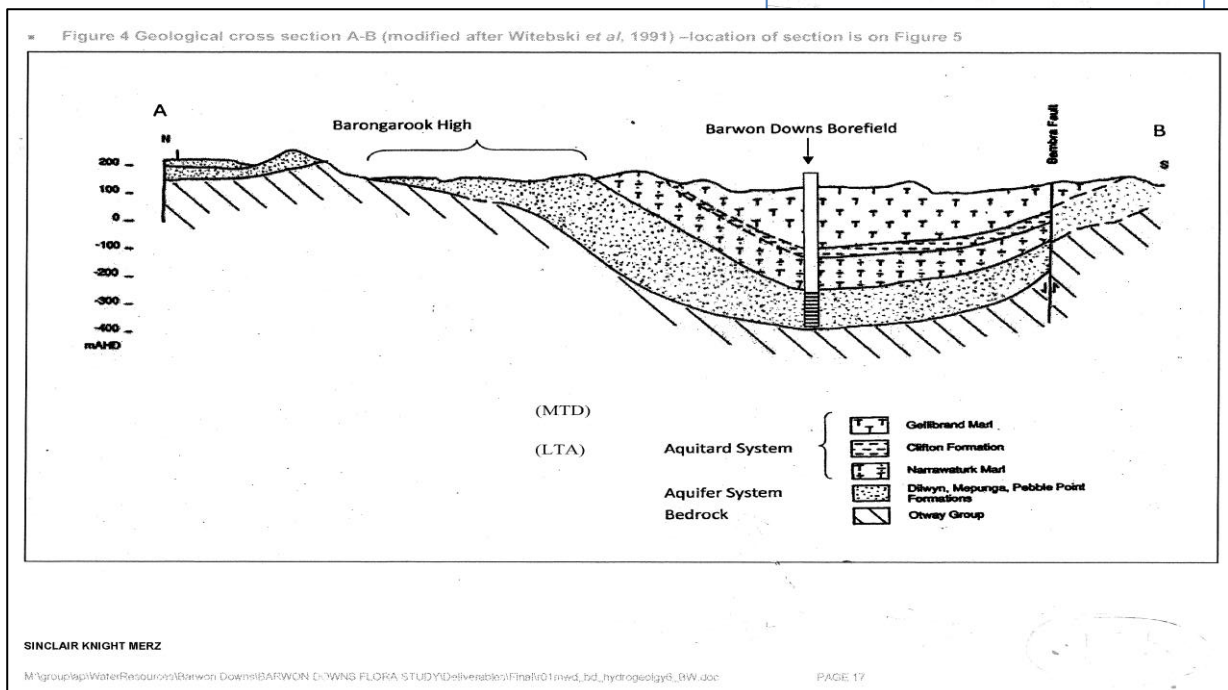
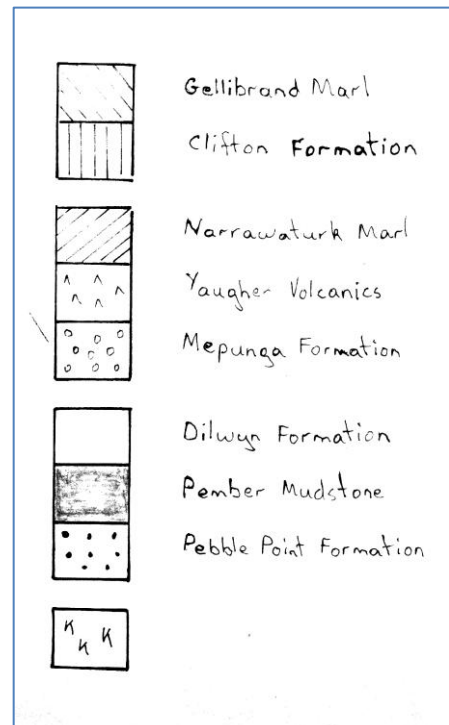
In 1995 Witebsky’s et al.⁽⁷⁹⁾ simulations indicated that these overlaying formations would play an important role acting as a significant source when extensive groundwater takes place. Extractions greater than 1,500 ML/year was seen as a significant development of the borefield. In this situation downwards leakage from overlaying formations was most likely to be a major source of recharge under stressed conditions. *“The immediately overlaying Narrawarturk Marl is up to 170m in thickness and grades from silty sand to marls. It has a very high storage capacity and within the borefield area is known to contain groundwater of good quality.”* Under undisturbed conditions an upward

hydraulic gradient sees the marls being recharged from below. Extract from the Barwon Downs Borefield and the process was expected to be reversed.

Even back in 1995 it was obvious that some regard should be taken of what was to happen in these formations of earth above the area of impact created by the borefield extractions.



Diagrams from Leonard.



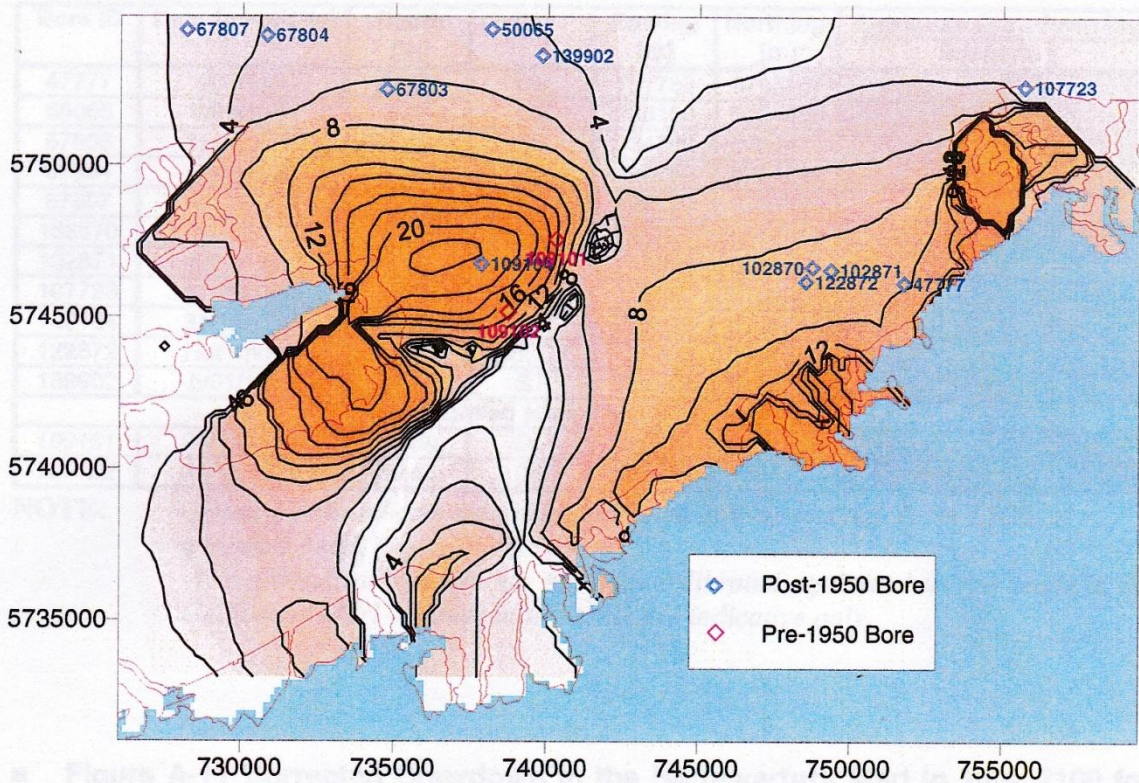
Another 2002 SKM⁽⁵⁶⁾ report threw additional light on the leakage possibility. Three additional pumping scenarios were modelled, numbered 5, 6 and 7. Number 6 was dropped from the discussion as Barwon Water advised SKM *“...that Scenario 6 is an unrealistic representation of any future water usage because it does not fit well with the requirements of their water supply system.”* As it turned out Scenario 6 was the closest scenario adopted during the Millennium Drought groundwater extraction period.

Also, *“...the analysis suggests that stream flows will never return to their undisturbed level in any of the scenarios.”*⁽⁵⁶⁾ Not to mention the amount of downward vertical leakage that might take place. However, even though there was a lack of data for the layers above the Eastern View Formation an attempt was made to model the impacts up to the year 2100.

“The unavailability of suitable bore monitoring data in the Gellibrand and Narrawarturk Marls has prevented effective calibration of the groundwater model in the shallow layers that overlie the aquifer. Model predictions in these layers are therefore not supported by calibration and validation processes that normally demonstrate the validity of a groundwater model. Accordingly there is considerable uncertainty associated with the predicted impacts on shallow bores in the Gellibrand and Narrawarturk Marls.”⁽⁵⁶⁾ The Clifton Formation aquifer is given no place in the modelling but would also eventually be impacted from downward leakage given time.

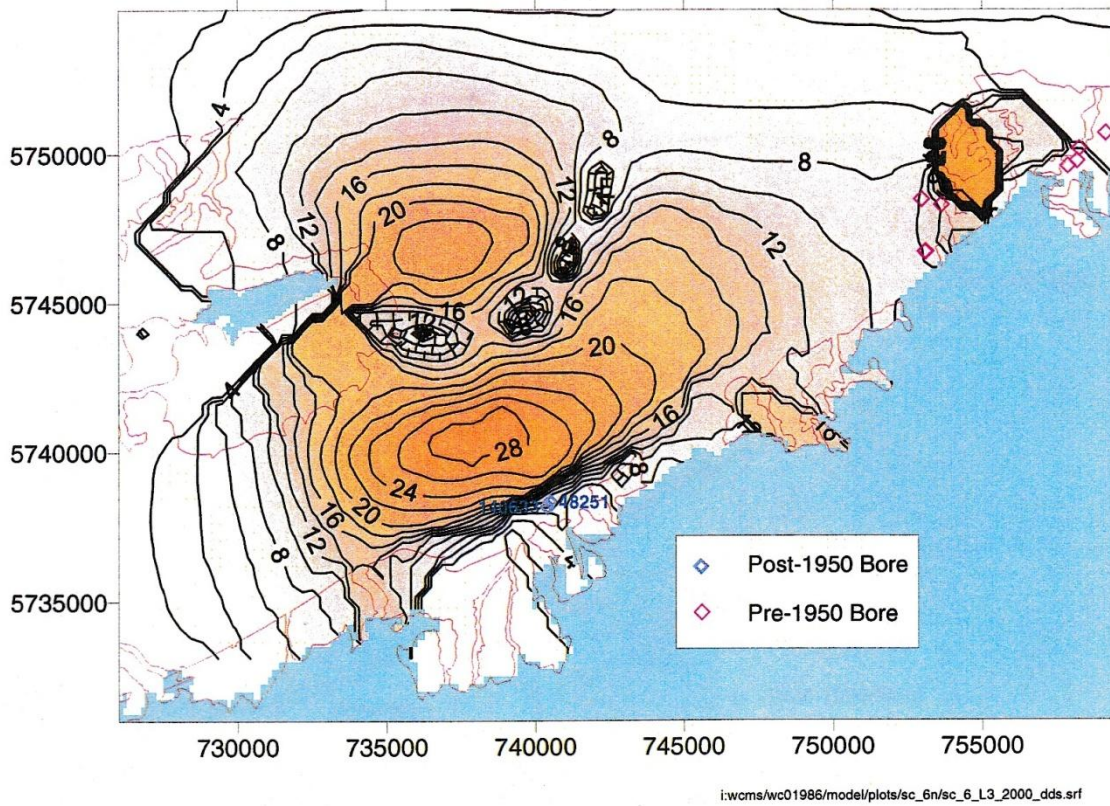
Taking into consideration the possibility of droughts in the 2020s, 2040s and 2090s, similar to the last century droughts, anticipated drawdowns in the Gellibrand and Narrawarturk Marls were modelled. The drawdowns were fairly similar in each of the Scenarios 5, 6 and 7. The following two drawdown maps taken from the 2002 SKM report,⁽⁵⁶⁾ indicate impact was expected in both the Gellibrand and Narrawarturk Marls.

■ **Figure A-9 Corrected Drawdown in the Gellibrand Marl in Year 2100 for Scenario 6**



Considering the possibility of downward vertical leakage having been discussed as far back as 1984,⁽⁴⁸⁾ combined with these two drawdown scenarios of 2002, emphasising the highly likelihood of a 50 m drawdown, it seems impossible that the licence conditions of 2004 did not reflect any consideration of downward vertical leakage.

■ **Figure A-11 Corrected Drawdown in the Narrawarturk Marl in Year 2100 for Scenario 6**



Evans⁽²⁹⁾⁽³⁰⁾ discusses time lag between pumping and impacts that can take place. He states the impact can range from immediate to a hundred or more years, and that impacts may not be observable until years after pumping ceases. The downward vertical leakage from overlaying marls and aquifers would fit into one of these slower to take effect impacts. Considering the notion of downward vertical leakage in pumping episodes has been recognised for many years, it is amazing that very little effort has been made to collect data regarding this phenomena in the Barwon downs Borefield situation.

Observation bores collecting drawdown data from the Clifton Formation and the Gellibrand and Narrawarturk Marls should have been put in place decades ago. The failure to do this is another example of not putting into place a licence condition that was blatantly obviously lacking.

In January 2016 I was sent draft maps from DELWP indicating observation bores collecting data in the Clifton Formation and the Narrawarturk Marl. These maps provided the following information, confirmed in the accompanying email.

	Bores in Gerangamete GMA	Bores in Gellibrand GMA
Narrawarturk Marl	0	0
Clifton Formation	3	0

It is extremely difficult to determine the amount of vertical leakage seeping down into the depleted aquifer until an observation bore network is drilled into these overlaying formations. Bores in each formation need to be in a netted situation.

B. Follow Up Recommendations Ignored.

In an effort to gain a clear understanding of how the hydrologically sensitive vegetation was going to respond to groundwater extraction at the Barwon Downs Borefield the first set of studies and data gathering recommendations were made in 1986.⁽³¹⁾ However, despite Barwon Water saying these studies were completed none were done. The first study was conducted in 1992.⁽¹³⁾

Year report finished.	Recommendations made.	No. of sites identified	Stated as new sites.	Previously Recommended	Year Implemented
1992 Ecology Australia ⁽¹³⁾	<ul style="list-style-type: none"> Develop a carefully designed monitoring program. Mark permanent sites Design a long term monitoring program Have control sites Investigate & implement amelioration 	82	82	Yes Yes Yes Yes	- - - -
2002 Ecology Australia ⁽¹⁴⁾	<ul style="list-style-type: none"> Design & implement a monitoring program Mark permanent sites Design a long term program Have control sites 	24	0	Yes Yes Yes Yes	- - - 2004

	<ul style="list-style-type: none"> • Determine frequency of monitoring • Monitor watertable at the sites 				
2008 Ecology Australia and SKM ⁽⁵⁵⁾	<ul style="list-style-type: none"> • Design & implement monitoring sites • Design a long term monitoring program • Mark permanent sites • Monitor water table at sites • Investigate the impact from pumping on these sites • Determine frequency of monitoring 	8	5	Yes Yes Yes Yes Yes Yes	- - 2008 - - -
2015 Jacobs (81)	<ul style="list-style-type: none"> • A new start is to be made and that this report outlines baseline conditions for future monitoring as recommended in previous flora surveys • Envisaged that future monitoring rounds will be able to use the data captured in this report as a baseline against which changes can be measured • Key questions to be analysed have been identified for each new site • Surface level at each site yet to be determined • There will be subsequent reports following 	14	14		

In 1992 numerous vegetation water sensitive sites were identified.⁽¹³⁾ However, over the course of the next three surveys,⁽¹⁴⁾⁽⁵⁵⁾⁽⁸¹⁾ sites could not be found; site locations were changed; grid co-ordinates a jumble; some sites removed; others included; site identification confusing; local knowledge ignored, and throughout, Barwon Water failed to carry out follow up recommendations that could have been used to gain a comprehensive understanding of the impacts on water sensitive vegetation sites within the drawdown influence of the Barwon Downs Borefield. Despite this, there is a strong and compelling case that the data that does exist, if used wisely, is sufficient to evaluate many of the impacts from groundwater extraction.

FINAL COMMENT

Thankfully, since March 2014 when discussions are raised at the Barwon Water Groundwater Community Reference Group challenging pre 2012 decisions, past experience, data and reports relating to the Barwon Downs Borefield operation have not been put aside using the excuse that past decisions were based on the best information at the time.

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However, much of this pre 2012 data is strenuously being regarded as past history, demanding a fresh start be made as outlined in the expanded monitoring program of 2013. And, that is another story.

Appendix One, draft Licence Condition up for discussion pre 2004 Licence

renewal.

LICENCE CONDITION:

Maintenance of Flow in Boundary Creek

Background

Groundwater extraction at the borefield reduces groundwater levels beneath Boundary Creek such that groundwater discharge ceases and the creek stops flowing in summer
Groundwater levels are drawn down quickly during pumping and recover more slowly when pumping ceases

To maintain flow in the creek BW will need to supply water to the creek to compensate for the loss of baseflow until groundwater levels recover sufficiently

A minimum flow needs to be provided along the creek to Yeodene, for environmental and D&S purposes

To achieve a minimum flow at Yeodene will require a greater input flow in the headwaters of the creek

Stream gauging at Yeodene is undertaken by DSE and information is currently obtained by BW quarterly

Water is taken from the creek above the Yeodene gauge for domestic and stock use and there is an on stream dam on the creek

It is considered unreasonable for BW to have to guarantee a flow at the Yeodene gauge as BW has no control over the amount of water taken from the creek.

1. Setting Objectives and Prescribing Limits

Objective :

To maintain a minimum flow in Boundary Creek for the environment and D&S users

Limits:

A flow of 2 ML/d must be provided at the head waters of the creek unless:

- groundwater levels the bores x, y and z have recovered to within ? m of full recovery level, or
- flow at the Yeodene gauge exceeds 1 ML/d between the 1st May and 31st November of each year.

Reporting and Review of Monitoring

Reporting:

BW must fit a meter at the point of water inflow at the head of the creek
The meter must be read weekly by BW

The metered data must be provided quarterly to the Authority

Stream gauging data from the Yeodene gauge (233228) must be obtained from the monitoring contractor at least at monthly intervals and provided to the Authority quarterly.

3. Compliance

Notification of exceedance:

If the flow provided to Boundary Creek by BW falls below 2ML/d and the bores have not recovered sufficiently, or there is insufficient flow at the Yeodene gauge as described above, the Authority must be notified within 7 days of this occurrence.

Appendix Two, draft Licence Condition up for discussion pre 2004 Licence renewal.

LICENCE CONDITION:

Protection of Riparian Vegetation

Background

Declining water levels below Boundary Creek due to pumping result in a lowered water table beneath vegetation adjacent to the creek

Whilst it is thought that such lowered groundwater levels are likely to affect the vegetation, the extent to which the vegetation is dependent on continuous high groundwater levels is not known

To determine whether or not the vegetation is dependent on high water tables, it is intended to undertake floral and groundwater level monitoring at Flora Site 25, as well as at another site to be selected on the creek, and compare changes with vegetation at similar control sites away from the influence of pumping

As the determination of dependency is likely to require a period of time similar to the term of this licence, the intention of this condition is to provide sufficient information to be able to implement protection measures, if required, upon licence renewal.

1. Setting Objectives and Prescribing Limits

Objective : To protect vegetation adjacent to Boundary Creek if it is found to be groundwater dependent

2. Monitoring Prescribing the Monitoring Network

Network Description: Floral Site 25 on Boundary Creek, plus a new site upstream of Site 25 and 4 control sites away from Boundary Creek (new sites to be specified)

Prescribing the Monitoring Activity

Monitoring Description: A floral survey will be undertaken at all sites in the network by a consultant approved by the Authority every 5 years after the commencement date of this licence

Reporting and Review of Monitoring

Reporting: The results of the floral survey will be provided to the Authority within 6 months of the completion of each 5 yearly survey
The report of the flora survey must be accompanied by a review of groundwater levels determined from bores adjacent to the flora sites

Review Description: Prior to renewing this licence, BW must provide the Authority with a report assessing the degree of dependence of the riparian vegetation adjacent to Boundary Creek on the regional groundwater system.

BIBLIOGRAPHY

1. Barnett, B. of Sinclair Knight Merz, 23rd May 2003: Recommendations for Groundwater Licence Conditions. Letter and Discussion documents to Paul Northey of Barwon Water. Cond_Letter. Doc WC01986
2. Barwon Water, 2005: Groundwater Licence No. 893889 Gerangamete Area 2004/05 Report to Southern Rural Water.
3. Barwon Water, 2006: Groundwater Licence No. 893889 Gerangamete Area 2005/06 Report to Southern Rural Water.
4. Barwon Water, 2007: Groundwater Licence No. 893889 Gerangamete Area 2006/07 Report to Southern Rural Water.
5. Barwon Water, 2008: Groundwater Licence No. 893889 Gerangamete Area 2007/08 Report to Southern Rural Water.
6. Barwon Water, 2009: Groundwater Licence No. 893889 Gerangamete Area 2008/09 Report to Southern Rural Water.
7. Barwon Water, 2010: Groundwater Licence No. 893889 Gerangamete Area 2009/10 Report to Southern Rural Water.
8. Barwon Water, 26 November 2013: Barwon Downs Monitoring Program, Stage 1, Field Investigations and Monitoring Program Scope. Prepared by Sinclair Knight Merz.
9. Belcher C. and O'Shea B. 1993: Inventory and Assessment of the Faunal Values of the Barwon Downs Aquifer Outcrop areas and associated streams, Otway Ranges, Victoria. Consultants report prepared for Barwon Waters. Ecosystems Environmental Consultants, RMB 4269 Timboon, Victoria.
10. Belcher C. January 2002: Terrestrial Fauna Survey of the Yeodene Study Area, Barwon Downs Aquifer Outcrop Area, Otway Ranges, Victoria. Consultants report prepared for Barwon Waters. Ecosystems Environmental Consultants, RMB 4269 Timboon, Victoria.
11. Blake. R & Associates, November 1995: South-West Coast Groundwater Investigations Priorities. Department of Conservation and Natural resources Water Resource Management Branch. Government Services Contract 1994/95.
12. Blake. R., June 2003: Discussion of SKM Flow Net in the Barwon Downs Graben. Discussion paper, unpublished. Presented to the Barwon Downs Groundwater Licence Renewal Panel.
13. Carr G. W. May 2002: Barwon Downs Aquifer Flora Re-Survey. Report Prepared for Barwon Water. Ecology Australia Pty., Ltd., Flora and Fauna Consultants, Fairfield, Victoria.
14. Carr G.W., Muir A.M., June 1994: Inventory And Assessment Of Floral And Faunal Values Of The Barwon Downs Aquifer Outcrop Areas And Associated Streams, Otway ranges, Victoria. Ecology Australia Pty. Ltd. Flora and fauna Consultants. Clifton Hill Victoria 3068. Prepared for Barwon Water.

15. Clifton R., Evans C. 2001: Environmental water requirements of groundwater dependent ecosystems. Environmental Flows Initiative Technical Report No. 2. Commonwealth of Australia, Canberra.
16. Corangamite Catchment Management Authority, February 2006: Environmental Flow Determination for the Barwon River; Final Report-Flow recommendations. 64 Dennis Street, Colac, Victoria, Australia.
17. Corangamite Catchment Management Authority, July 2006: Assessment of Environmental Flow Requirements for the Gellibrand River. Recommendations, Revision E. Earth Tech Natural Resources Group – Melbourne, Victoria.
18. Department of Minerals & Energy, September 1984: Regional Water Strategy Plan for the South-Western Region of Victoria, Stage one, Augmentation of Geelong's Water Supply to the year 1995. A Submission to the Natural Resources and Environment Committee inquiry into Water Resources Management. Government Printer.
19. Department of Natural Resources and Environment Victoria, January 1998: Permissible Annual Volume Project , The Gerangamete GMA. Sinclair Knight Merz.
20. Department of Natural Resources and Environment. 1995: Groundwater Development Options and Environmental Impacts – Barwon Downs Graben, South-Western Victoria.
21. Department of Primary Industries 2008: Corangamite Fishery Management Plan. Fisheries Victoria Management Report Series No. 59, Department of Primary Industries, Melbourne.
22. Department of Sustainability and Environment, December 2006: State Observation Bore Network Program. Regional Groundwater Monitoring Network Review for the Deep Aquifer System in the South West Victoria. Victorian Government, Australia. Prepared by GHD.
23. Department of Sustainability and Environment, Observation Bore Data, Victorian Government, Australia. @ www.vicwaterdata.net
24. Department of Sustainability and Environment, September 2006: Report for Newlingrook GMA Review of Groundwater Resources. Prepared by GHD Pty Ltd. 31/19400/119159.
25. EAL Consulting Service in Conjunction with the Environmental Analysis Laboratory, Southern Cross University for Land and Water Resources Otway Catchment (LAWROC), October 2010: Preliminary Inland Acid Sulfate Soil Assessment Report, Investigation of Wetland Habitats, Boundary Creek Catchment and Kawarren. Draft report, unpublished.
26. EPA Victoria, September 2006: Hydrogeological Assessment (Groundwater Quality) Guidelines. Victorian Government, Australia.
27. Evans R., 1986: Subsidence Estimates for Groundwater Development at Barwon Downs, Kawarren and Gellibrand. Rural Water Commission, Victoria.
28. Evans R., 2005: Double Accounting of Surface & Groundwater Resources – the tyranny of time lag. Outlook Conference. Land and Water Australian Senior Research Fellowship.
29. Evans R., April 2007: The Impact of Groundwater Use on Australia's Rivers – Exploring the technical, management and policy challenges. Product codes PR071282. Land & Water, Australia, Australian Government. (Based on the Land and

Water Senior Research Fellowship Report by Dr. Richard Evans, Principal Hydrogeologist, Sinclair Knight Merz.)

30. Evans R., April 2007: The Impact of Groundwater Use on Australia's Rivers – Exploring the technical, management and policy challenges. Technical Report Product codes PR071282 and PR071283. Land & Water, Australia, Australian Government. (Based on the Land and Water Senior Research Fellowship Report by Dr. Richard Evans, Principal Hydrogeologist, Sinclair Knight Merz.)
31. Farmar-Bowers Q., October 1986: Environmental Issues Barwon Downs Groundwater. South-Western Region Water Management Strategy.
32. Freshwater Ecology section Arthur Rylah Institute for Environmental Research Department of Natural Resources and Environment, Heidelberg, Victoria. November-December 2001: Boundary Creek Fish Fauna Survey.
33. Gardiner M. J. August 2007: Otway Water – At What Price. Book 2.
34. Gardiner M. J. February 2010: Otway Water – Boundary Creek and the Big Swamp. Book 11. (www.otwaywater.com.au)
35. Gardiner M. J. March 2008: Otway Water – the Summaries.
36. Gardiner M. J., November 2009: Otway Water – Waves of Obfuscation! Book 10.
37. Gardiner M., June 2007: Otway Water –Who Gives A Damn?
38. Gardiner, M. J. October 2008: Otway Water – One Giant Environmental Footprint. Book 8.
39. Gardiner, M. J. September 2009: Otway Water – Barwon Downs Flora Studies 1986-2009. Book 9.
40. Geelong and District Water Board, 26 June 1989: Barwon Downs Groundwater Test Pumping Program, Progress Report No. 7. Water Resources and Headworks System Section, Systems Planning Branch.
41. Geelong and District Water Board, August 1989: Barwon Downs Groundwater Test Pumping Program, Progress Report No. 8. Water Resources and Headworks System Section, Systems Planning Branch.
42. Geelong and District Water Board, March 1989: Submission to Natural resources and Environment Committee Inquiry into Water resources Management in Victoria, South-Western Region Water Management Strategy.
43. Geelong and District Water Board, September 1992: Contract Brief. Inventories and Assessments of the Flora and Fauna Values of the Barwon Downs Aquifer Outcrop Areas and the Streams Draining Them.
44. Greig P., October 2002: Submission on groundwater Licence 893889 to Southern Rural Water – Bernie O’Kane BRWA Licence Renewal Panel, East Melbourne.
45. Groundwater Licence No. 893889, Southern Rural Water – issued to Barwon Water, Geelong, Victoria.
46. Hatton T. Evans R. 1998: Dependence of ecosystems on groundwater and its significance to Australia. Occasional Paper No. 12/98. Land and Water Resources Research and Development Corporation, CSIRO Australia.
47. HydroTechnology, 1994: Delineation of the Barongarook High Recharge Area, Kawarren Groundwater Resource Evaluation. Government Service Contract, CC/30410.001A/2.
48. Leonard J., Department of Minerals and Energy. September 1984: Submission to Natural resources and Environment Committee Inquiry into Water resources Management, regional Water Strategy Plan for South-Western region of Victoria,

Stage 1, Augmentation of Geelong's Water Supply to the Year 1995. Geological Survey of Victoria. Victorian Government.

49. McInnes N., July 2008: Boundary Creek Colac Forrest Road Victoria Australia. Upper Barwon Landcare Network.(www.ubln.org.au)
50. Natural Resources and Environment Committee (NREC), Parliament of Victoria, November 1989: Inquiry into Water Resources Management in Victoria South-Western region Water Management Strategy. No. 83 Government Printer, Melbourne.
51. Northey. Paul., 17 June 2002: Barwon Downs Aquifer- Historical, existing and Future Development. A briefing for the Barwon Downs Licence renewal Project Group (1st Meeting).
52. Petrides B., Cartwright I.,2006:The Hydrology and Hydrogeochemistry of the Barwon Downs Graben aquifer, Southwestern Victoria, Australia. Hydrological Journal (2006) 14: 809-826.
53. Rural Water Commission of Victoria. October-December 1986: Artificial Recharge Pilot Study. Boundary Creek at Yeo. Report on First Infiltration Experiment.
54. Saddler S.R. 1992a: Survey of Fish, Crustacea and Habitat of the Colac Region. A consultants report, prepared for the Geelong and District Water Board. May 1992.
55. Sinclair Knight Merz, 14 April 2009: Barwon Downs Flora Study 2008. Final 1. Barwon Water, Victoria Australia.
56. Sinclair Knight Merz, June 2002:Barwon Downs Groundwater Investigation Stage II, Report on Additional Scenarios.
57. Sinclair Knight Merz, 23 May 2003: Recommendations for Groundwater Licence Conditions. Discussion documents on the Licence Number 89338 conditions. (Cond_Letter. Doc, WC01986).
58. Sinclair Knight Merz, February 2002: Barwon Downs Groundwater Study Stage 2. Impacts on Boundary Creek. Barwon Water.
59. Sinclair Knight Merz, May 2001:Barwon Downs Groundwater Flow and Subsidence Modelling Project. Report on the Groundwater Flow Model Draft D.
60. Sinclair Knight Merz, November 1995: Corangamite Regional Salinity Implementation Group – Mandatory Monitoring Report.
61. Smith I, 20th August 2002: Report to Barwon Downs Licence Renewal – Project Group, Analysis of Ecological Survey Reports (Flora, Fish & Fauna).
62. Smith I, 8th November 2002: Barwon Downs Licence Renewal – Report to Panel. Ecological Survey Recommendations (Flora, Fish & Fauna Survey requirements.
63. Southern Rural Water, Victoria, 2005:Groundwater Licence No. 893889. Water Act 1989, Section 51 and 67.
64. Stanley D. R., 1991: Preliminary Groundwater Resource Evaluation of the Kawarren Sub-Region of the Barwon Downs Graben. Rural Water Corporation Investigations Branch. Unpublished Report. 1991/36.
65. Tunbridge B. R., March 1988: Environmental Flows and Fish Populations of Waters in the South-Western Region of Victoria. Technical Report Series No. 65. Arthur Rylah Institute for Environmental Research, Victoria.
66. Victorian Catchment Management Council, 2007: Catchment Condition Report 2007. Victorian State Government, Victoria, Australia.
67. Victorian Government Gazette, 1664, G 28, 10 July 2008. Tim Holding MP, Minister for Water.

68. Victorian Government Gazette, SPECIAL, No. S 107 Wednesday 4 June 2003: State Environment Protection Policy Waters of Victoria.
69. Victorian Government Gazette, SPECIAL, No. S 160 Wednesday 17 December 1997: State Environment Protection Policy Groundwaters of Victoria.
70. Victorian Government, 4 June 2003: Variation to State Environment Protection Policy, Waters of Victoria. Victoria Government Gazette No. S 107, Page 25, 45 Groundwater Management .
71. Victorian Government, November 2006. Victorian Government Gazette No. G 44. Permissible Consumptive Volume Groundwater Order 2006 under the Water Act 1989.
72. Victorian State Government Gazette, 1 July 2007: Statement of Obligation – Barwon Region Water Authority. Under sections 4(2)a and 8(1)a Water Industry Act 1994. Victorian Government, Melbourne.
73. Victorian State Government Gazette, 17 December 1997, Number S 160: State Environment Protection Policy – Groundwaters of Victoria. Under the Environment Protection Act 1970.
74. Victorian State Government Gazette, 20 June 2007: Statement of Obligations – Corangamite Catchment Authority. Under Catchment & Land Protection Act 1994.
75. Victorian State Government, July 2008: Ministerial Guidelines for Licensing Groundwater for Urban Water Supply. Water Act 1989. Victorian Government, Melbourne.
76. Water Resources Management of Victoria. November 1989. Inquiry into Water Resources Management in Victoria South-Western Region Water Management Strategy. No. 83. Government Printer, Melbourne.
77. Western Region, Our Water Our Future, May 2009: Western Region Sustainable Water Strategy. Media release. Victorian Government, Melbourne.
78. Williams G: The Gellibrand River: Balancing environmental and urban water demand in a climate change. Corangamite Catchment Management Authority, Colac, Victoria. Australia.
79. Witebsky S., Jayatilaka C. and Shugg A. J., November 1995: Groundwater Development Options and Environmental Impacts. Barwon Downs Graben, South-Western Victoria. Department of Natural Resources and Environment.
80. Woodward Clyde, March 1999: Gellibrand Groundwater Management Area (GMA) – Permissible Annual Volume (PAV). Prepared for the Department of Natural Resources and Environment.
81. Jacobs 7 July 2015: Barwon Downs Vegetation Monitoring, Vegetation Monitoring report. Barwon Water. RP_ISO 19000 / C .