OTWAY WATER BOOK 21

An Aquifer Divide Shift & Study of Observation Bore Hydrographs of the Eastern View Formation (EVF) Aquifers in the Gerangamete and Gellibrand Groundwater Management Areas.

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June 2013

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Foreword

Quentin Farmar-Bowers PhD

When I wrote my report on the Barwon Downs groundwater program in 1986 I had been in the Victorian public service for 13 years working on public land planning and environmental and social issues associated with water programs in rural areas. I was aware of the enormous range of attitudes within the water industry to environmental issues, attitudes that were not necessarily related to the person's age. So, on meeting an engineer, planner or manager for the first time, there was no way of knowing whether or not they would be supportive of social and environmental investigations and be willing to follow through on relevant recommendations.

Because of this, my approach at the time was to do my job and trust that the system (the bureaucratic process) would ensure a follow through to secure compliance with the spirit and letter of public policy.

I knew however that many middle and senior bureaucrats were influential enough to ensure that their own interpretation of public policy prevailed. So, the success of environmental work depended to a large degree on who was in charge. It is not that the bureaucrats who were inclined to give environmental issues a very low priority were anti-public interest; they just interpreted public interest as the very specific goal of 'water supply' and thought that 'any means' to achieve that goal would be deemed legitimate.

There were two failings in the bureaucratic process at the time that I think allowed this single mindedness to prosper. The first failing was the paucity of debate and evaluation processes. There was no in-depth debate about projects and no independent review process to question what was being achieved and how it was being achieved. Environmental work, like the work I was doing tended not to be taken too seriously. I felt that senior public servants had the perception that as professionals, they knew best what to do, how to do it and should be left to get on with it. The second failing was senior people's

interpretation of neo-liberal philosophies. To me, it seemed that senior bureaucrats believed that water supply was 'a good' that was necessary for economic growth that benefited everybody so everyone should pay for it. In contrast, environmental issues were seen as items of value only to 'greenies' and that as such only 'greenies' should pay for them. Somehow the logic was that if you wanted a river that supported native biodiversity then you should buy your own river system. This meant that when the budget for the whole water project got tight (as it usually did) works to protect the environment were the ones that got axed; enabling the project would come in 'on budget'. The logic being that the decision to axe the environmental works and the consequences would only disadvantage a minority of the population.

The saga of groundwater pumping at Barwon Downs and the environmental issues on Boundary Creek and the Big Swamp that Malcolm Gardiner and colleagues have been addressing for decades is an amazing story. It illustrates the two failings in the bureaucratic processes I mentioned above; lack of debate and evaluation and the absolute priority given to economic growth. It also illustrates four other processes that we need to understand and value in order to make good decisions for the future of this groundwater scheme and also to guide the processes agencies choose to use in the developing of all other public infrastructures such as water resource developments.

The first of these four processes and I think the most spectacular is Malcolm Gardiner and colleagues' tenacious work in seeking information and influence. I call this process 'citizen interaction'. In this case, the citizen interaction has spanned decades and involves trying to understand what is going on, what environmental degradation has resulted and why it has been allowed to continue for so long. It has also provided an information base that has helped private individuals interact effectively with other infrastructure proposals. Having such interested and dedicated people in the community ought to be valued highly as their activities, and perhaps very existence, provides feedback that will help improve decision making for public infrastructures and how they are to be operated.

The second process, or rather processes, is the ecological responses to the works that have gone on in the region since the beginning of the 1980s that involve water, soils and fire. Understanding 'nature's response' to people's use of the environment is very important for current and future management of the environment in which we live. Understanding this process requires that we set the information about current and recent changes into the longer term frame of white settlement and Aboriginal use of the area, especially Aboriginal use of the wetlands in the regions. It is easy to imagine that the wetlands would have been an important local resource. Understanding the ecological history of the landscape and its values to human beings will provide decision makers with the knowledge that will help them choose futures that honour that past and hopefully lead them to decisions that will sustain the unique values of that landscape.

The third process is the governance of the locality and how this fits into the ambitions of the regional population, particularly those ambitions that concern gaining benefits from developing and extracting resources from the locality. Governance ought to be based on an appreciation of the range of ambitions people have and what the landscape naturally provides. It seems particularly important to know the current values that a landscape provides as changes can damage these values. The context of this governance is partly regional to the extent that the water resources extracted support regional development including the growth of regional centres, notably Geelong. The context is also State and National as policies and sentiments at these levels greatly influence local governance. Very often, governments make top down decisions that have determined change at the regional level. In contract, this third process is about governance (not government) in which values to be maintained and ideas about developments that are useful and appropriate can flow upwards from local and regional to state and national levels. Governance processes that have shaped and continue to shape the use of the locality and region are not going to be unique to this part of Victoria; it is very likely that the story here and the lessons that might be able to be drawn will guide people wanting to improve governance in other regions and states.

The fourth process is what I refer to as 'future-ising'; what are we going to do next? At any one time we can envisage that the future starts now. Although bygones are bygones we still need to evaluate and understand the past in order to set our sights on achieving a future that corrects the negatives of the past and aims to create a better future for us all. The most important building block to generate a 'future-ising story' about how people are going to move on to generate the next episode of the Barwon Downs' story, is the dedication of the citizens to working out what the real Barwon Downs story is and telling it. Integrated management has been a buzz phrase for many decades and the Barwon Downs story is potentially a great opportunity to practice integration as its foundation is conversation and agreement among stakeholders (agencies and citizens). An interested and informed citizenry is an asset to regional governance. The knowledge citizens have of the situation and their aspirations need to be valued and used in decisions that will have an impact on them, their region and on the environments in which they live. The 'future-ising story' needs to include a chapter on the ecological challenges of the region as we will be facing enormous changes in the coming decades especially from climate change and biodiversity loss. Development pressures are coming from the desire of many people to increase the extraction of natural resources, such as water, to fuel exports and the economic opportunities associated with globalisation and to facilitate regional population growth. The 'future-ising story' needs a chapter on governance to identify the problems and highlight what has worked well and what changes will support better governance in future. I am using the term governance not government because the future is about how people, all people, make decisions about the region and the contexts in which it operates.

The Barwon Downs story is an ongoing saga that has been documented by Malcolm Gardiner in his 21 books and by publications for government agencies and consultants. Although this is a small area in a small catchment, what has happened and how it has occurred highlights issues that need to be understood and used in developing more effective natural resource management. Barwon Downs now needs a 'future-ising story' to motivate people to adjust

existing decision processes as well as strategies, plans and policies. While I have no idea just what that future-ising story will contain, I suspect that it will include ideas about new processes in regional natural resource management to improve integrity in governance and especially to hear and act on the voices of local people. If well prepared, this story will provide a blueprint for how to go about preparing other 'future-ising stories' about the many issues that exist in natural resource management that are currently mired in conflict and controversy.

Quentin Farmar-Bowers PhD

CONTENTS

INTRODUCTION

In the late 1970s when Boundary Creek began having a "trickle" of days of no flow and by the middle of the 1980s many summer days of no flow, the signs were present that something was seriously wrong. Acidity levels in the creek increased to an alarming rate and after a particularly wet few years in the early 1990s upper sections of the Big Swamp had dried out sufficiently enough to catch fire.

By 2008 there were many more events taking place that indicated there was an Actual Acid Sulfate problem in the Big Swamp, a wetland through which Boundary Creek flowed. Barwon Water, Southern Rural Water, the Department of Sustainability & Environment, the Department of Primary Industries, the Corangamite Catchment Authority, the Environment Protection Authority and the Colac Otway Shire denied any responsibility, would not assist with any funding and did nothing. As a consequence a local Landcare Group, LAWROC, commissioned, the Southern Cross University's Environmental Laboratory to assess the Big Swamp and other sites in the area for Potential and Actual Acid Sulfate Soils. The Big Swamp tested out as a serious Freshwater Inland Actual Acid Sulfate Soil site, one of the worst in Australia. This prompted the Colac Otway Shire to lobby and successfully form a committee of authority representatives.

With the results of this report pending the above mentioned authorities, as a group called the Corangamite Inland Acid Sulfate Soil Steering Committee (the EPA declined to be a member) decided to fund a joint investigation with the La Trobe University on Acid Sulfate Soils. The Big Swamp was to be included in this study.

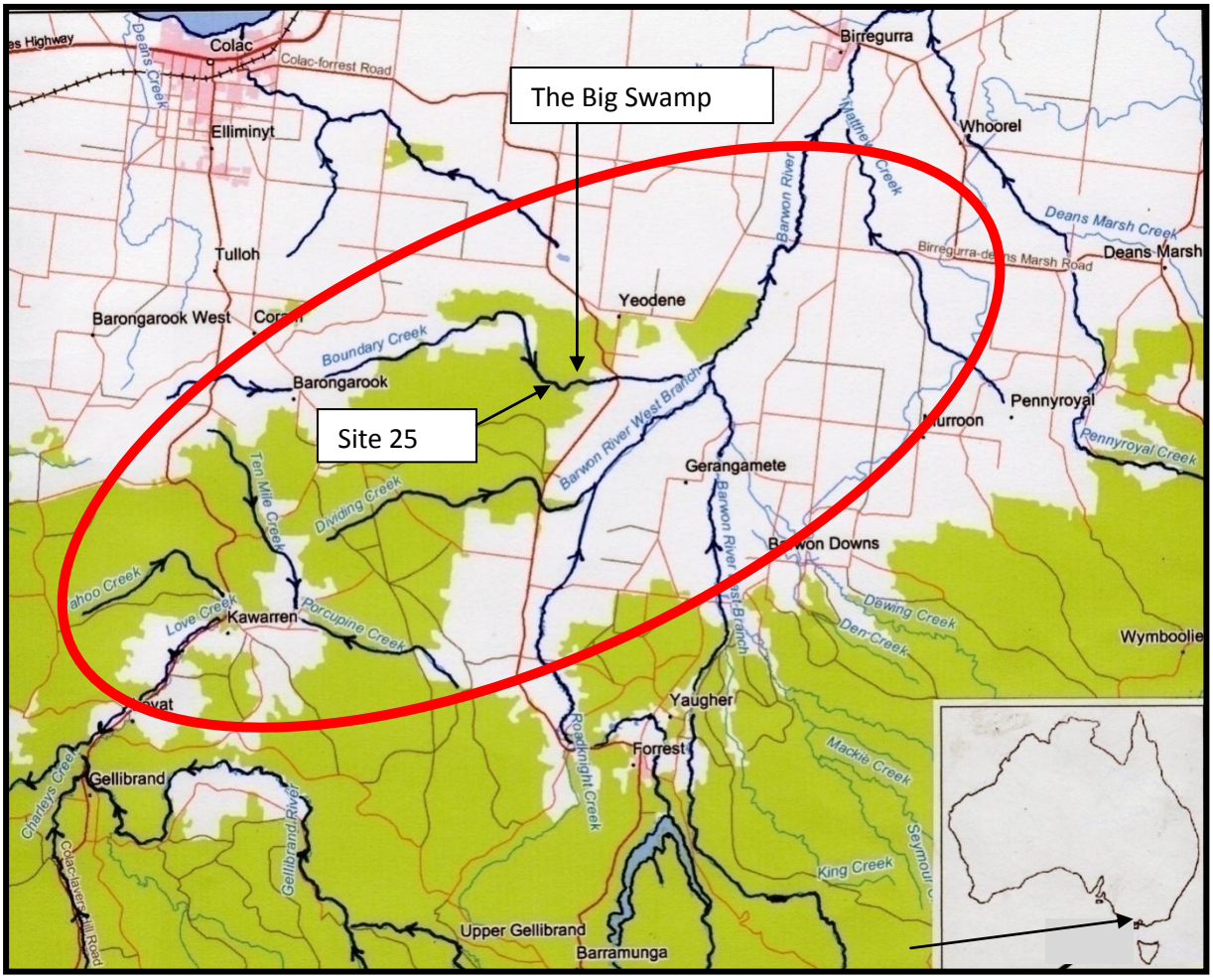
Repeated request to include investigating the cause(s) for the Big Swamp drying out have fallen on deaf ears for over 4 years. In February 2010 these words formed part of the introduction to Otway Water Book 11.

> ***"If authorities are so tardy investigating formal complaints of toxic acidified, heavy metal laden waters along Boundary Creek, it is anticipated that investigating the cause would take considerably longer."***

Still nothing has been done.
However, ***"At the Corangamite Inland Acid Sulfate Soils Steering Committee meeting held on 24 August 2012 Council's representative moved a motion that the committee investigate the cost and scope of investigating the cause(s) of the acidification of the "Big Swamp" at Yeodene. The motion was supported by the committee. Council's representative on the committee developed the scope for the investigation and has sought quotes from suitably qualified agencies. The scope for the investigation is attached to this report. Quotes were sought and obtained from suitably qualified agencies indentified through the Corqngamite inland Acid sulfate Soils Steering Committee. The range of the costs received in these quotes varied from $200.000 to $300,000."*** (Colac Otway Shire, Ordinary Council Meeting, Item OM121912-15, page 103, 19 December Meeting 2012.)
Outcome: cause investigation – no action has been taken.

This book supplements the material presented in Otway Water Book 19, confirming that groundwater extraction at the Barwon Downs Borefield is the major contributing causal factor that has lead to the Big Swamp drying out.

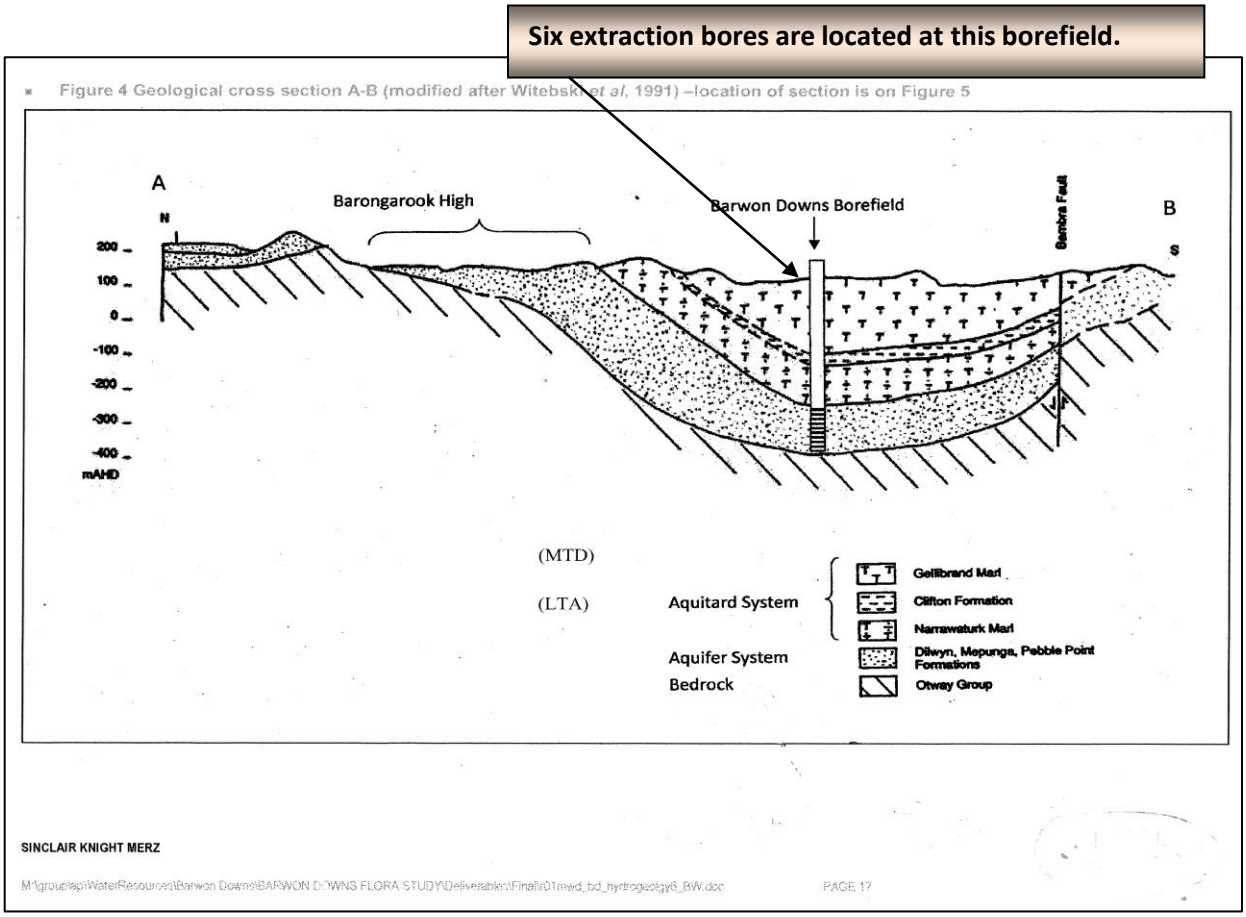
LOCATION MAP.



Otway Ranges, Victoria, AUSTRALIA.

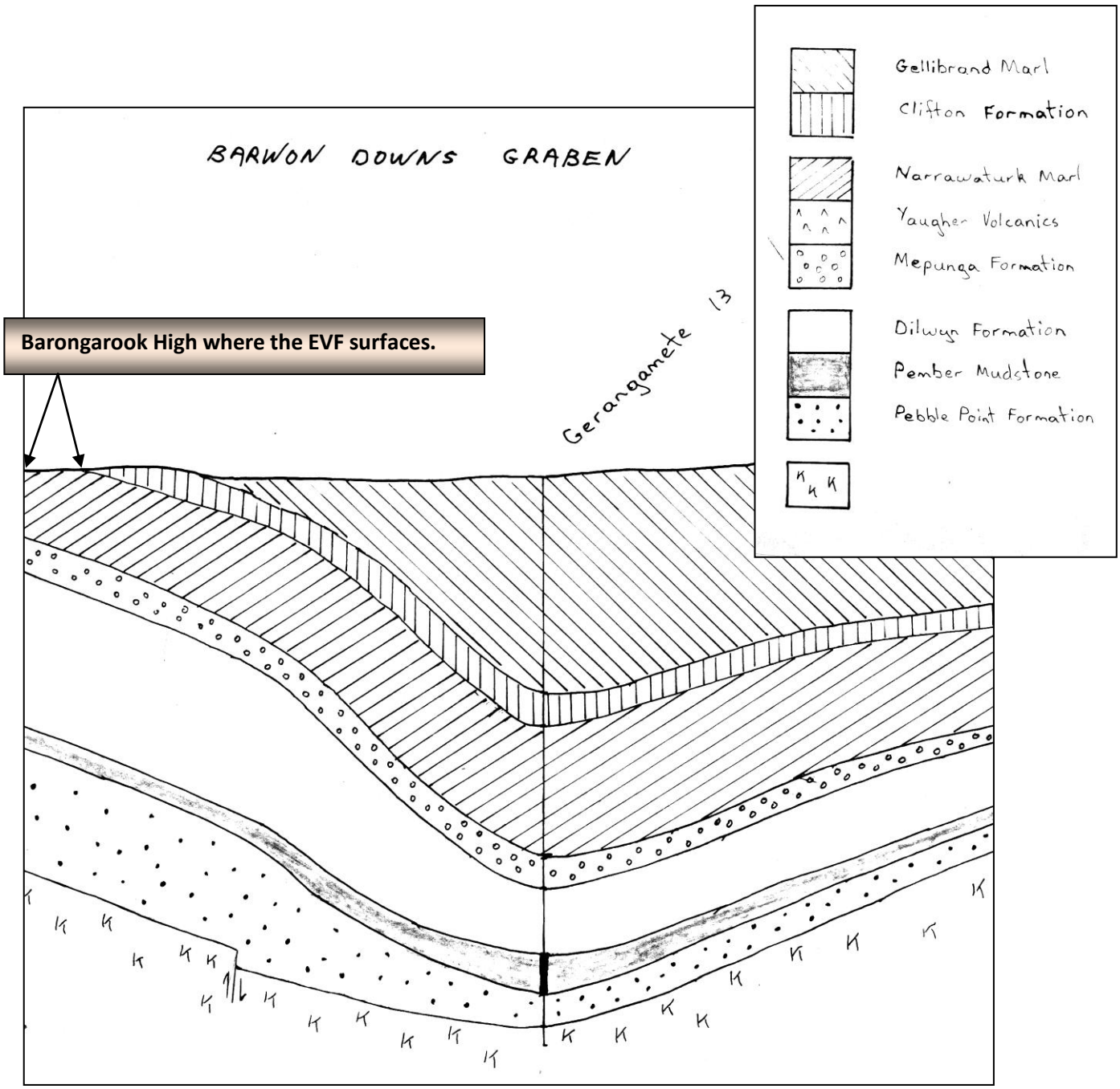
This study area encompasses sections of the Barongarook Creek Catchment; Boundary Creek a tributary of the Barwon River; Ten Mile Creek and Loves Creek tributaries of the Gellibrand River and sections of the Gellibrand River Catchment.

CHAPTER ONE
Recharge Area, Barwon Downs Borefield.



<u>SOURCE:</u> Barwon Water 2008-09 Flora Study.[9]

The aquifer system, the Eastern View Formation (EVF), that the Barwon Downs Borefield taps into rises and surfaces in the Barongarook High Region. Leonard[8] calculated that 18 square kilometres of the Barongarook High is the major recharge area for the Barwon Downs Borefield. Hydro Technology[7] later calculated this intake area to be 12 square kilometres. Every study conducted on this area agrees that the Barongarook High is the major recharge area for the aquifer system that the Barwon Downs Borefield taps into.
These same reports state that between 10 to 12 km^2 of the exposed aquifer in the Barongarook High recharges into the Kawarren/Gellibrand branch of the EVF.



SOURCE: Leonard.[8]

Extraction Bore Gerangamete 13(G 13)(ID bore number 64229) and the six extraction bores located at the Barwon Downs Borefield, for some unexplained reason, are not available on the Southern Rural Water website hydrograph data base. Yeo 40 (ID 1909130) is another significant observation bore that has not been included on the SRW website.

"The connectivity of Boundary Creek and the Eastern View Formation is not in dispute."

(Peter Harris, Secretary of the Dept. Of Sustainability & Environment, 7 July 2009, Ref: SEC005678, File: C5/07/3073.)

CHAPTER TWO
Extractions from the Barwon Downs Borefield.

Pre 1982
The first test pump in the Barwon Downs Borefield area was conducted in 1970 followed by an approximately 6 months extraction in 1975, a 3 months extraction in late 1977 and 1 month in late 1978.[12] A pilot production bore was sunk in 1977.[12] Unfortunately, the extraction rates were not mentioned when reported in the Witebsky et al. report. [12] Barwon Water, [5] the regional water authority involved cannot locate any extraction rates pre 1988.

1982-83
During the drought of 1982-83 Barwon Water extracted around 8000 ML of groundwater from the Barwon Downs Borefield.[12] This has been quoted as approximately 50% of Geelong's water requirements. This water successfully prevented the Greater Geelong and District running out of water.

1986
Farmar-Bowers[4] determined that extracting around 1,600 ML/year from the Barwon Downs Borefield would most likely be sustainable with few if any environmental impacts.

1986-1990
Over 25,000 ML were extracted in a stress test pump and as stated Barwon Water cannot locate these extractions.

1995
A comprehensive evaluation of this stress test was completed by Witebsky et. al[12] and this report recommended 1,500 ML/year extraction would have little environmental impact and that 4,000 ML/year would begin to place environmental stresses discernible in Boundary Creek and the adjoining areas.

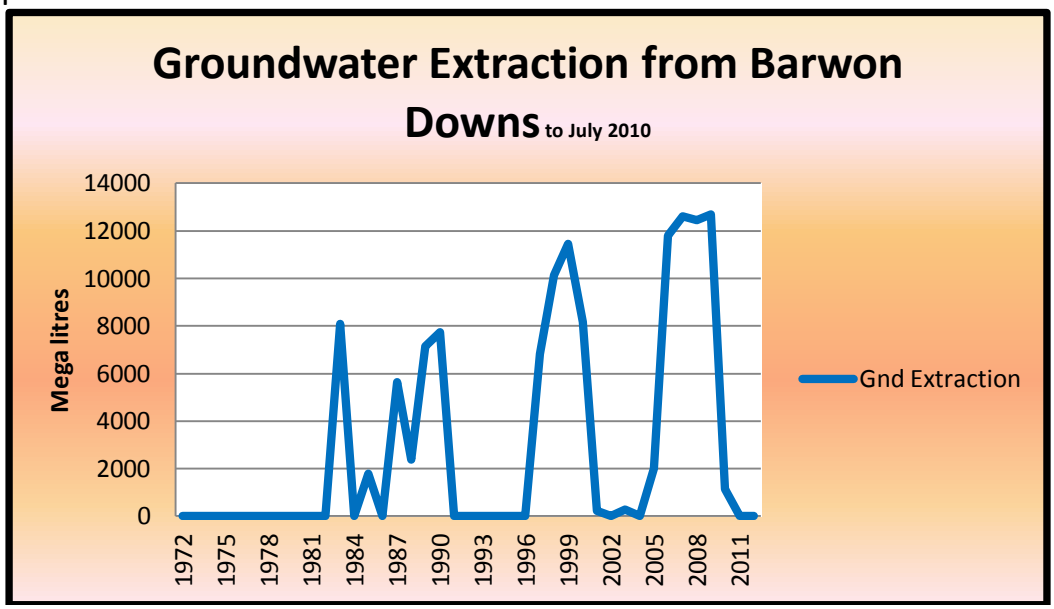
1995
Barwon Water was issued with a licence to extract 12,000 ML/year. No groundwater extraction took place until September 1997. This licence was extended to 12,600 ML/year some time later.

The very next Month, October 1997
In October1997, Jo Donovan, Licensing Supervisor West of Southern Rural Water, wrote that the Permissible Annual Volume for the Gerangamete

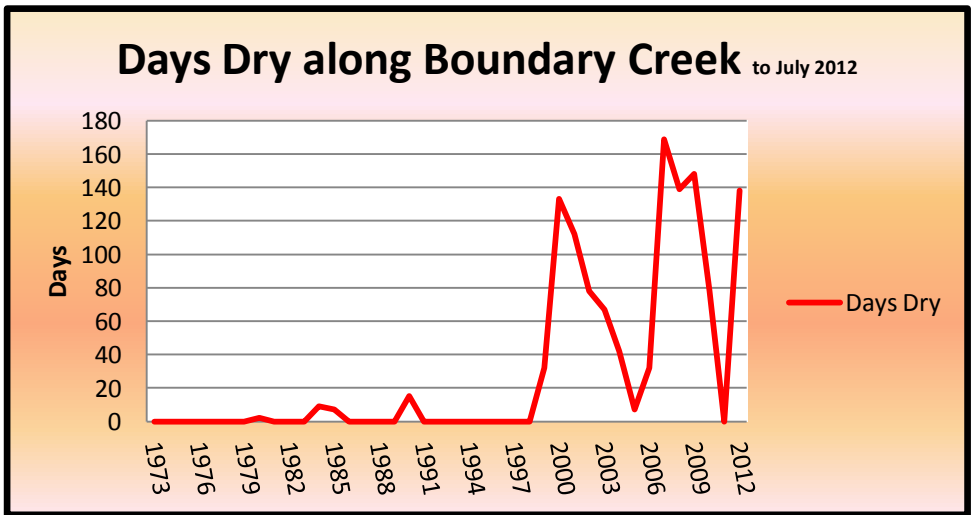
Groundwater Management Area had been calculated to be 4,000 ML/year.[5]
(The Barwon Downs Borefield is in the Gerangamete Groundwater Management Area.)

2004

In 2004 Barwon Water's licence was renewed allowing the extraction of 20,000 ML/year from the Barwon Downs Borefield, with no more than 80,000 extracted in any 10 year period and no more than 400,000 ML over a 100 year period.



SOURCES: Barwon Water, Southern rural Water,



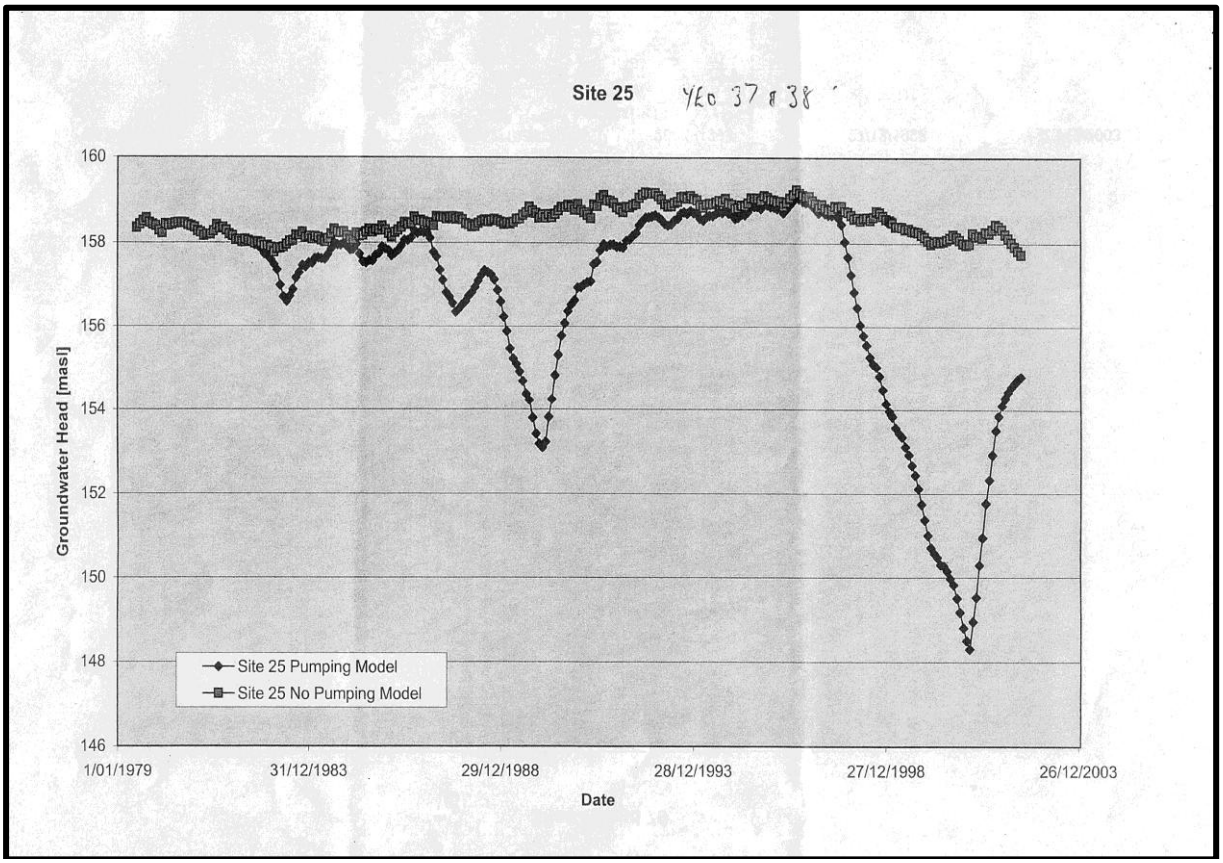
SOURCE: Vic Water Data Warehouse website.

The correlation between extraction and days the creek is dry is extremely high.

"Groundwater extraction at the borefield reduces groundwater levels beneath Boundary Creek such that groundwater discharge ceases and the creek stops flowing in summer."(see page 50)

CHAPTER THREE
Hydrograph with No Groundwater Extraction .

When reviewing the 12,600 ML/year licence in 2003 Hoxley (SKM) presented the following graph to a review committee[10] charged with determining the 2004 groundwater extraction licence.

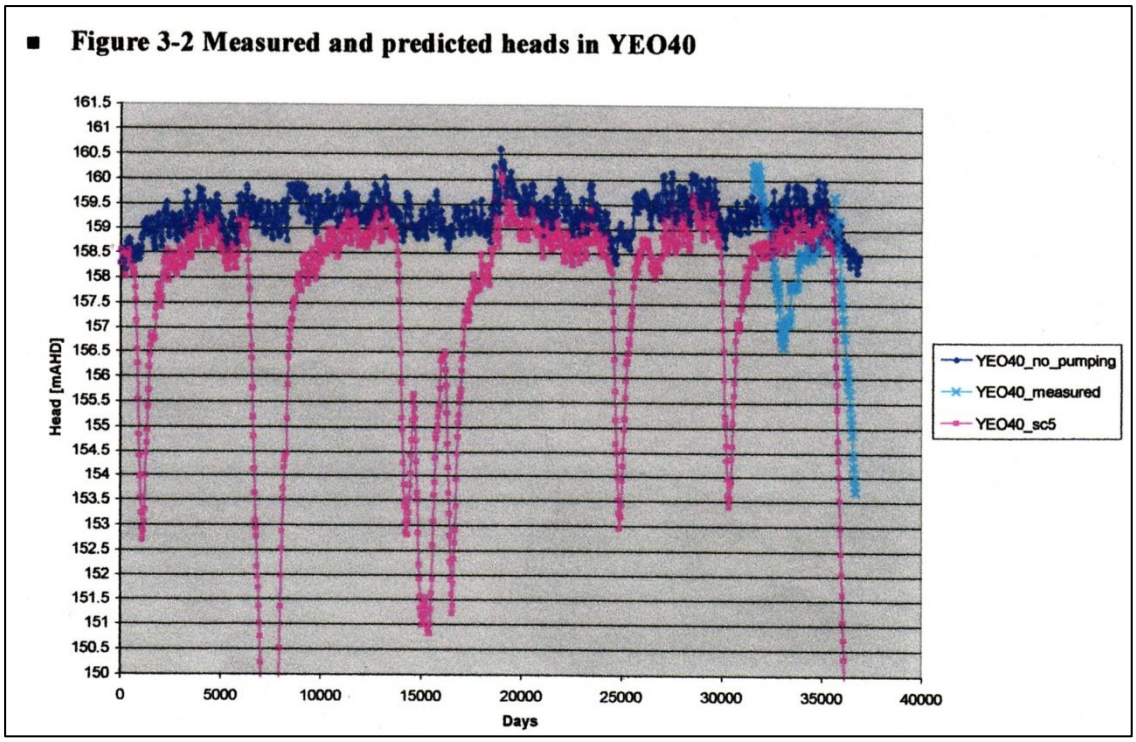


(When these graphs were obtained under the Freedom Of Information Act there was no explanation why the "*Yeo 37 & 38*" had been placed on the top of this graph.)

Site 25 (see page 10), a flora observation site,[2] is in the Barongarook High Region just above the area locally known as the Big Swamp (see page 10).

Observation bores Yeo 37 and 38 tap into the EVF.

This graph suggests that there has been a profound influence on the flora Site 25 just upstream of the Big Swamp and indicates that a similar non pumping scenario for the Big Swamp would show the swamp maintaining its saturation.



SOURCE: **SKM 14 May 2003 Recommendations for Groundwater Licence Conditions.**

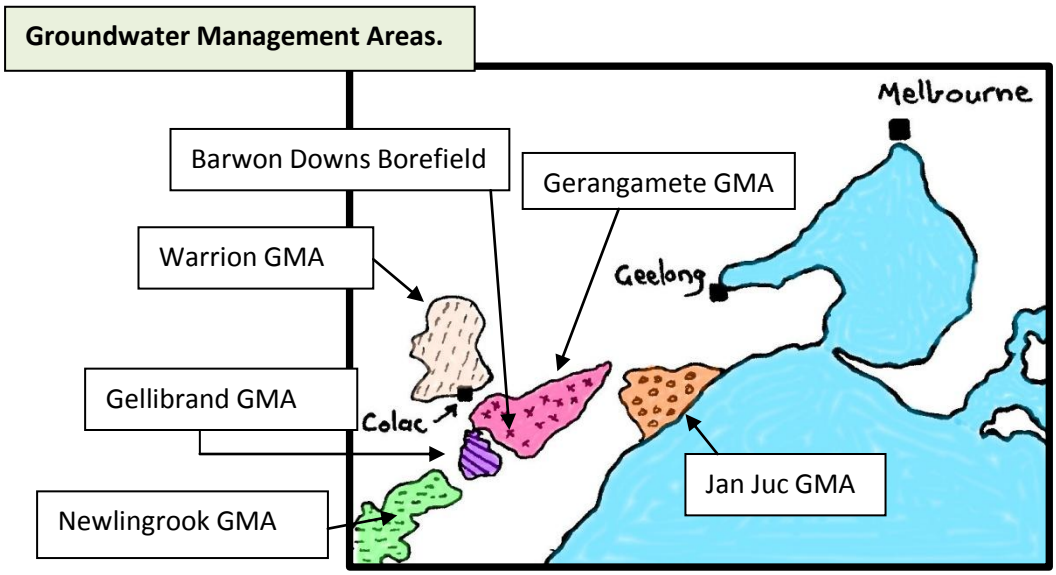
It is extremely significant, in this graph, to note that the hydrograph for Yeo 40 under the no pumping scenario is depicted as remaining above or slightly below the 158.5 mAHD. This level has been set as the trigger for the releasing of supplementary flows into the Boundary Creek system (see pages 57-59).

The measured data for the Yeo 40 hydrograph found on page 23 shows that since the extraction of groundwater at the Barwon Downs Borefield the water table has most often been metres below this trigger level.

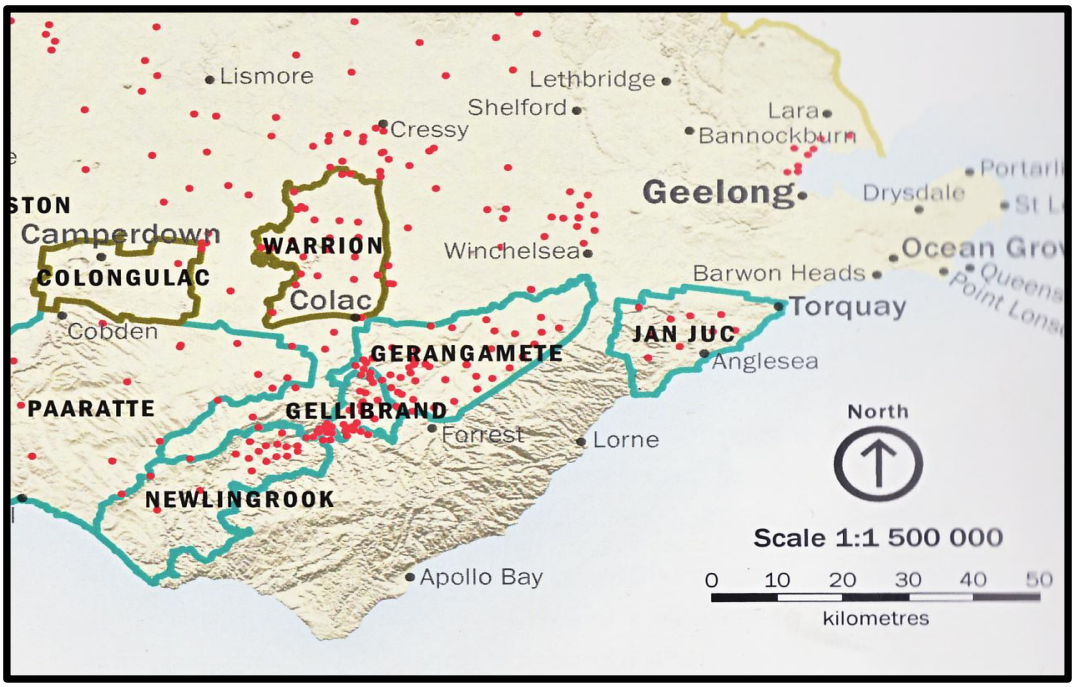
It would also appear that there is a discrepancy between the measured data above and that presented on the Vic Water Data Warehouse (page 23).

CHAPTER FOUR
Groundwater Management Area Boundaries.

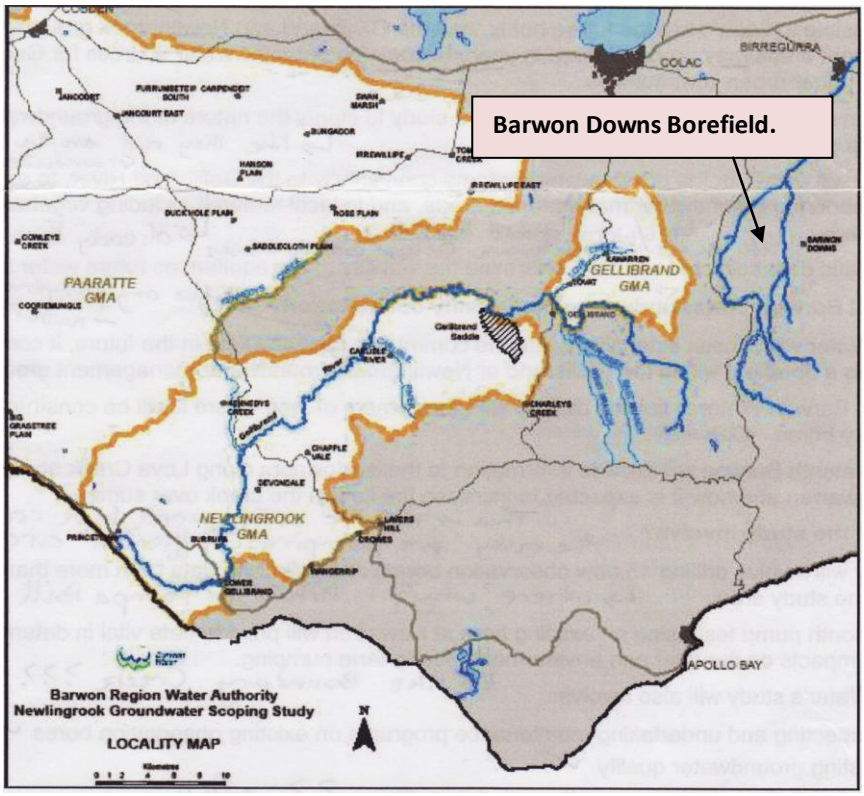
The Gellibrand and Gerangamete Groundwater Management Areas have sections sharing a common boundary.



<u>MAP SOURCE</u>: Our Water Our Future, June 2005 , State Water Report 2003-2004.

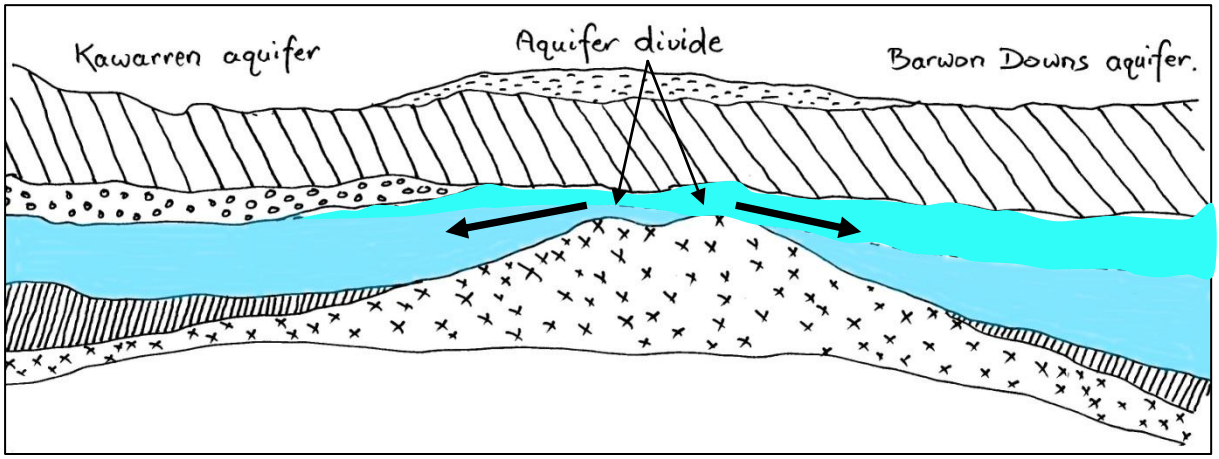


<u>MAP SOURCE</u>: Southern Rural Water/Australian Government National Water Commission, "South West Victoria Groundwater Atlas 2012."



MAP SOURCE: Barwon Water Locality Map.

The Newlingrook, Gellibrand and Gerangamete Groundwater Management Areas have been zoned based on particular characteristic allowing a certain amount of separation from one another. The Gellibrand Saddle creates this separation from the Newlingrook GMA while the Yeo Dome has a similar impact between the Gellibrand and Gerangamete GMAs.



Representation of the thinning of the Eastern View Formation over the Yeo Dome area.

Hydro Technology[(6)(7)] discusses in detail the thinning of the EVF over this area and determines that an aquifer divide exists in this area (see pages 19 and 46).

Note: **Official Groundwater Management Area Maps are...**
Newlingrook Groundwater Management Area map is PLAN No. LEGL./04-153.
Gellibrand GMA map is PLAN No .LEGL./14-134, and
Gerangamete GMA map is PLAN No. LEGL./04-135

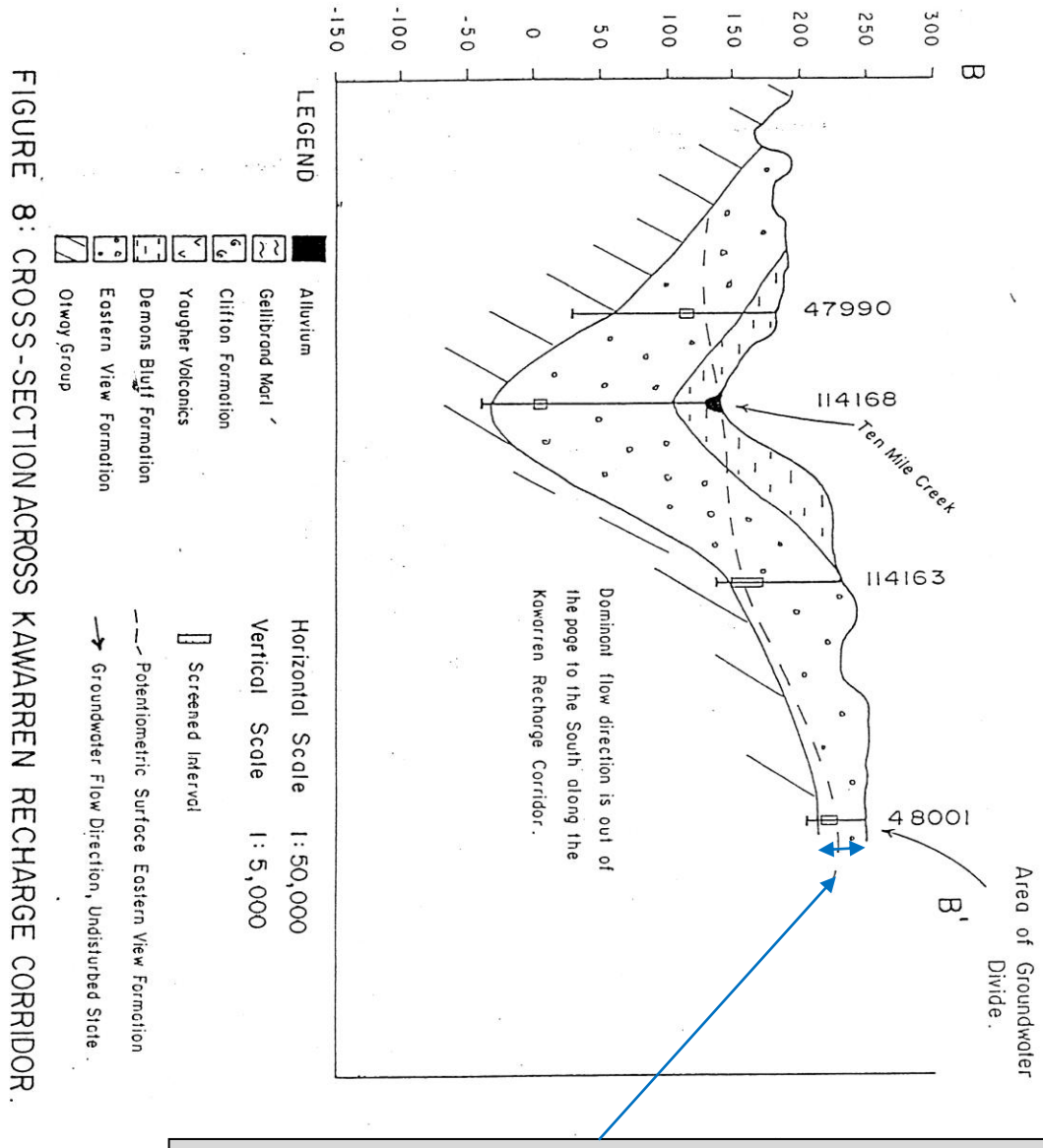


FIGURE 8: CROSS-SECTION ACROSS KAWARREN RECHARGE CORRIDOR.

Thinning of the EVF over the uplift to the Barwon Downs Borefield.

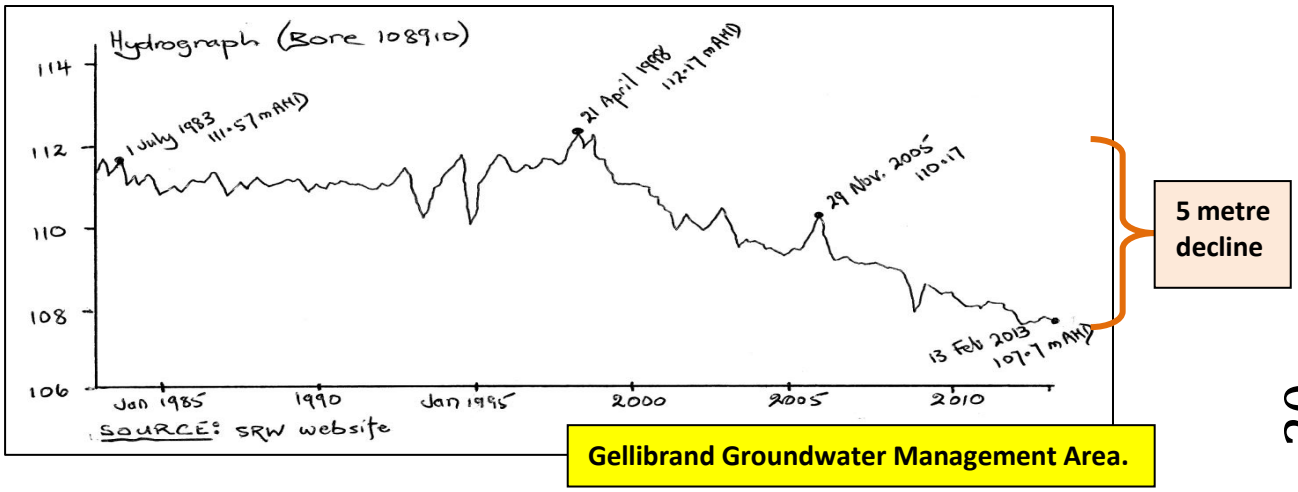
SOURCE: Hydro Technology[7]

CHAPTER FIVE
Drawdown.

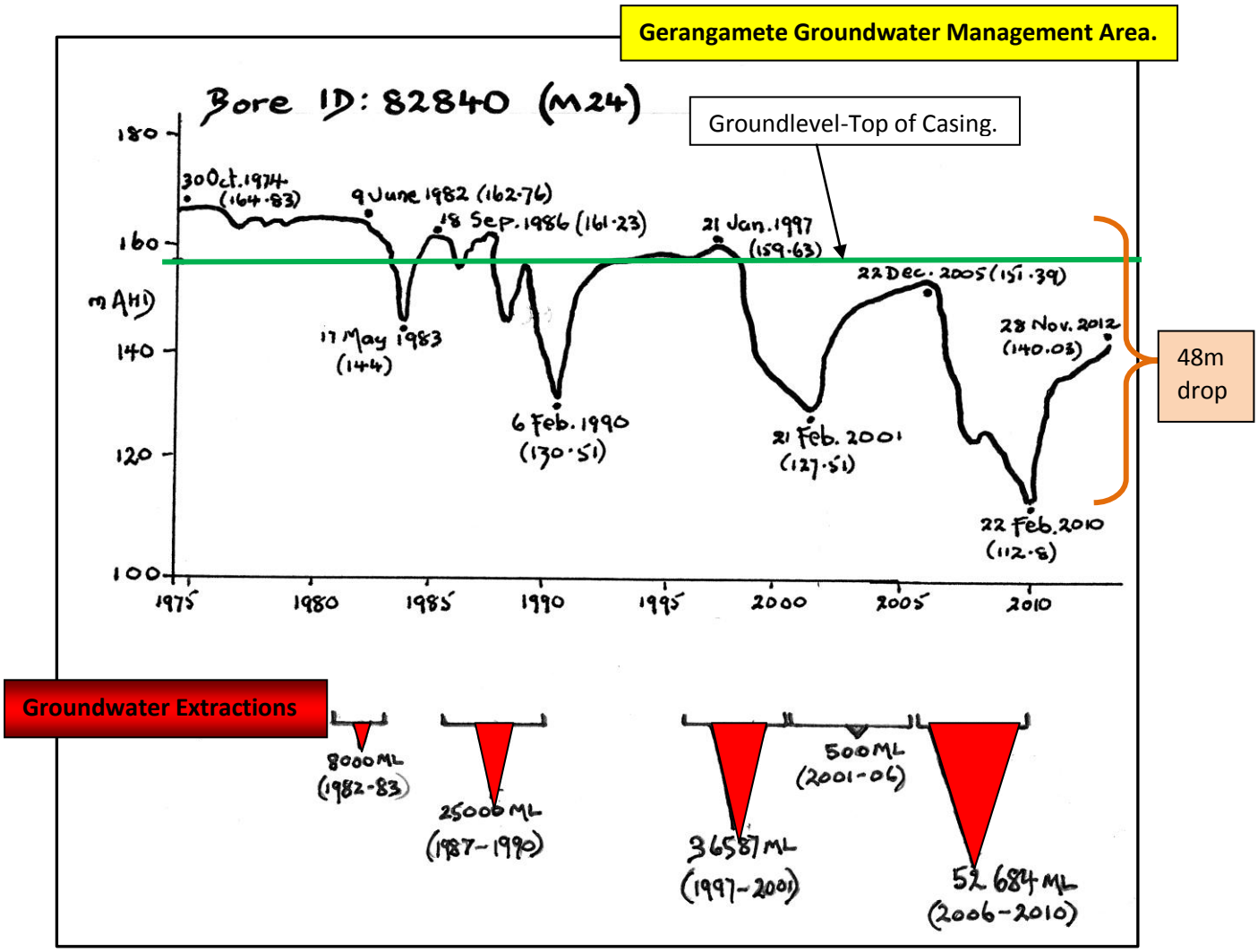
A 2006 study conducted by the Department of Sustainability and Environment titled, "***Regional Groundwater Monitoring Network Review for the Deep Water Aquifer System in South West Victoria***."[3] stated that regional groundwater was declining at rates less than 10 centimetres a year. It also goes on to say that at the current rate of decline, water-tables will drop in the order of one metre in ten years. This was taking into account climate change, drought and present groundwater extraction in the South West. Unfortunately, this study did not include the Barwon Downs Borefield area of influence where the aquifer has been lowered 30 metres in numerous observation bores and up to 60 metres at the Barwon Downs Borefield extraction point.

Southern Rural Water Newsletter 2012.

In a letter sent out to water rate payers Southern Rural Water (SRW) in November 2012, Second Report, referred to the Newlingrook, Gellibrand and Jan Juc Groundwater Management Areas and stated these GMAs as having groundwater declines ranging from nil and stable up to 4 metres drop for the 15 year period 1997-2012. This report made no comment on the Gerangamete Groundwater Management Area (Gerang.GMA). Perhaps, the dramatic declines in the Gerangamete GMA hydrographs presented in the next chapter are too difficult for SRW to explain. Similarly, this may explain the omission of data at the SRW website for many of the State observation bores in the Gerangamete GMA.



This hydrograph shows the relationship between groundwater extraction events in the Barwon Downs area and the impact it has had on water table drawdown.

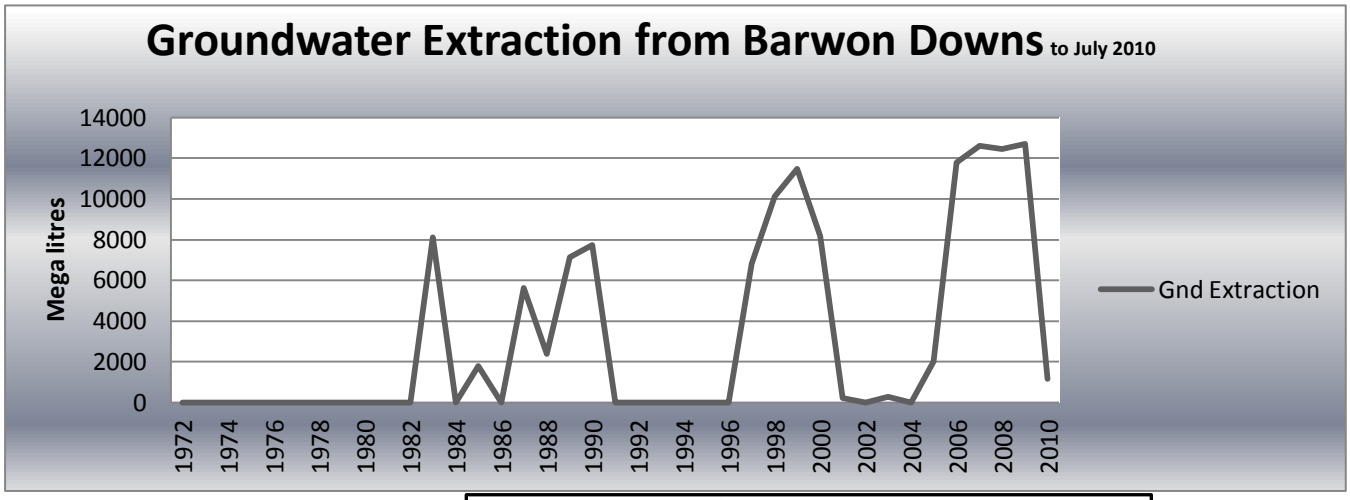


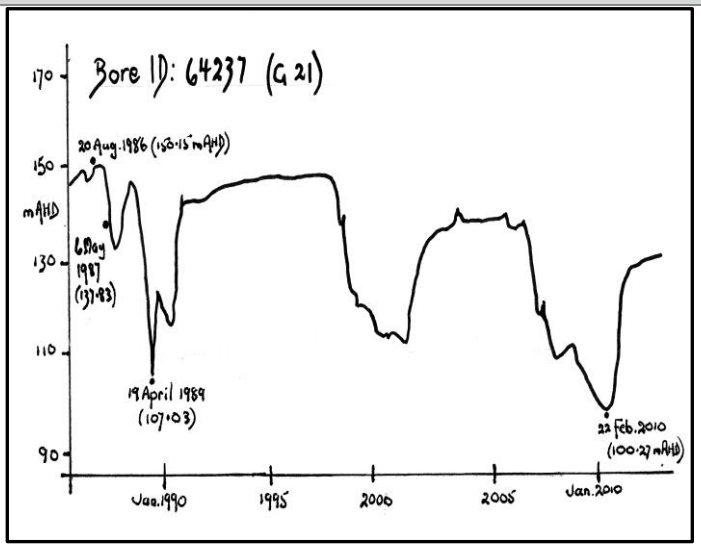
Hydrograph Data Source: Southern Rural Water Website.

Statement in the draft Licence Conditions of 2003 that was not included in the final licence.

"Groundwater levels are drawn down quickly during pumping and recover more slowly when pumping ceases."

(See page 50)





These two graphs have been manipulated in an attempt to line up the years of groundwater extraction with the observation bore recordings for the same period.

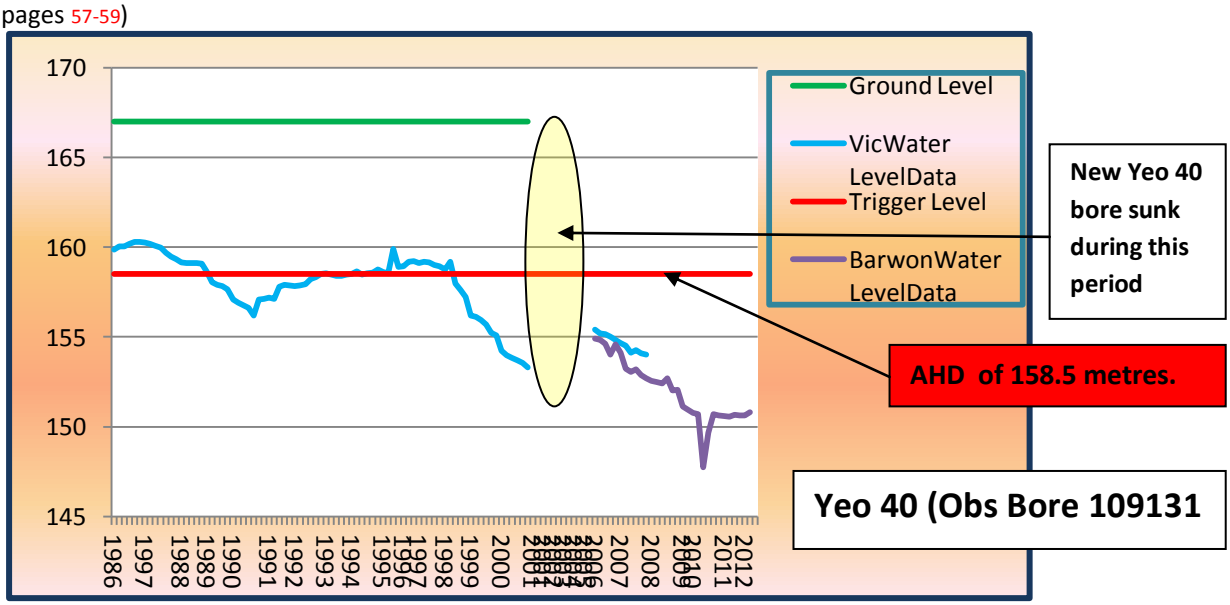
During extraction periods the bore levels drop and then begin to recover after pumping ceases.

This close correlation is repeated in many of the hydrographs (see Chapter Eight, pages 25-37) within the residual drawdown area of the Gerangamete Groundwater Management Area.

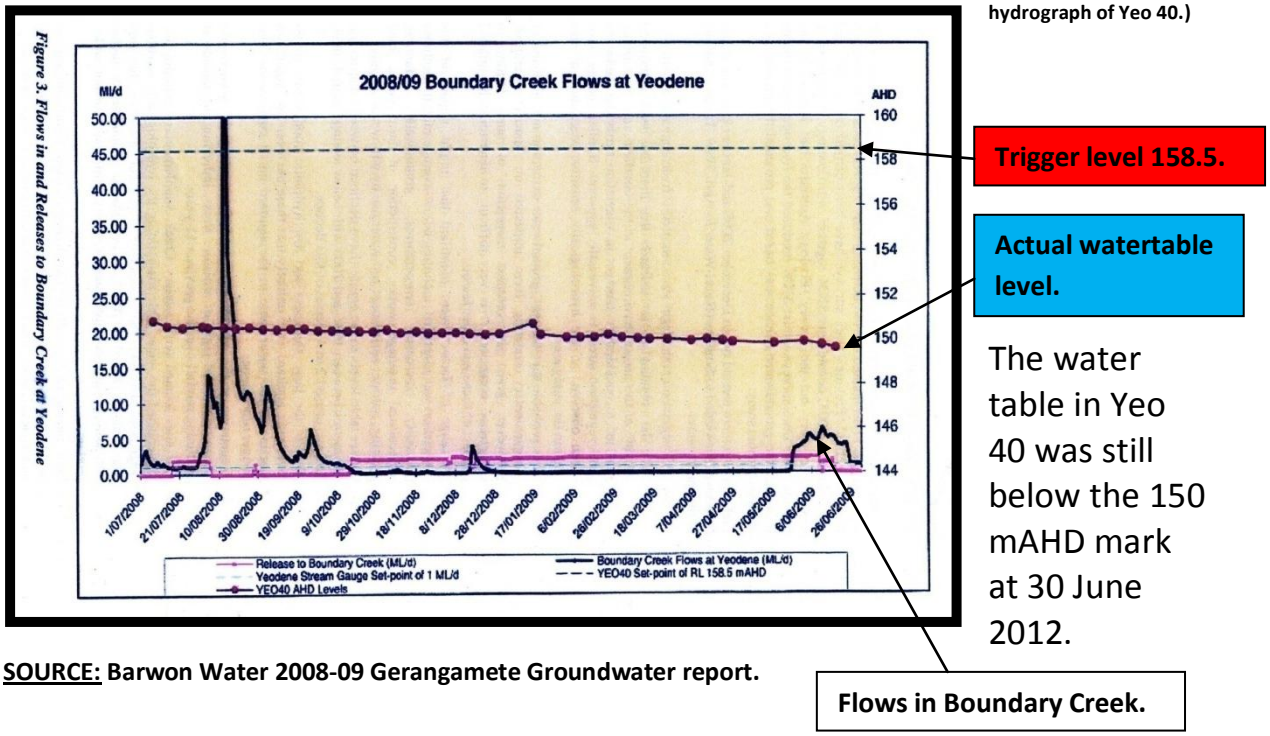
CHAPTER SIX

Yeo 40 .

Otway Water Book 19, pages 44, 45 and 91 explains how Yeo 40 (ID 109131) has been designated with a trigger level of 158.5 mAHD at which point supplementary flows are to be released into Boundary Creek. SKM calculated that if the water level in Yeo 40 dropped below 158 mAHD, discharge from the EVF aquifer into Boundary Creek would begin to decease.(also see Appendix Four, pages 57-59)



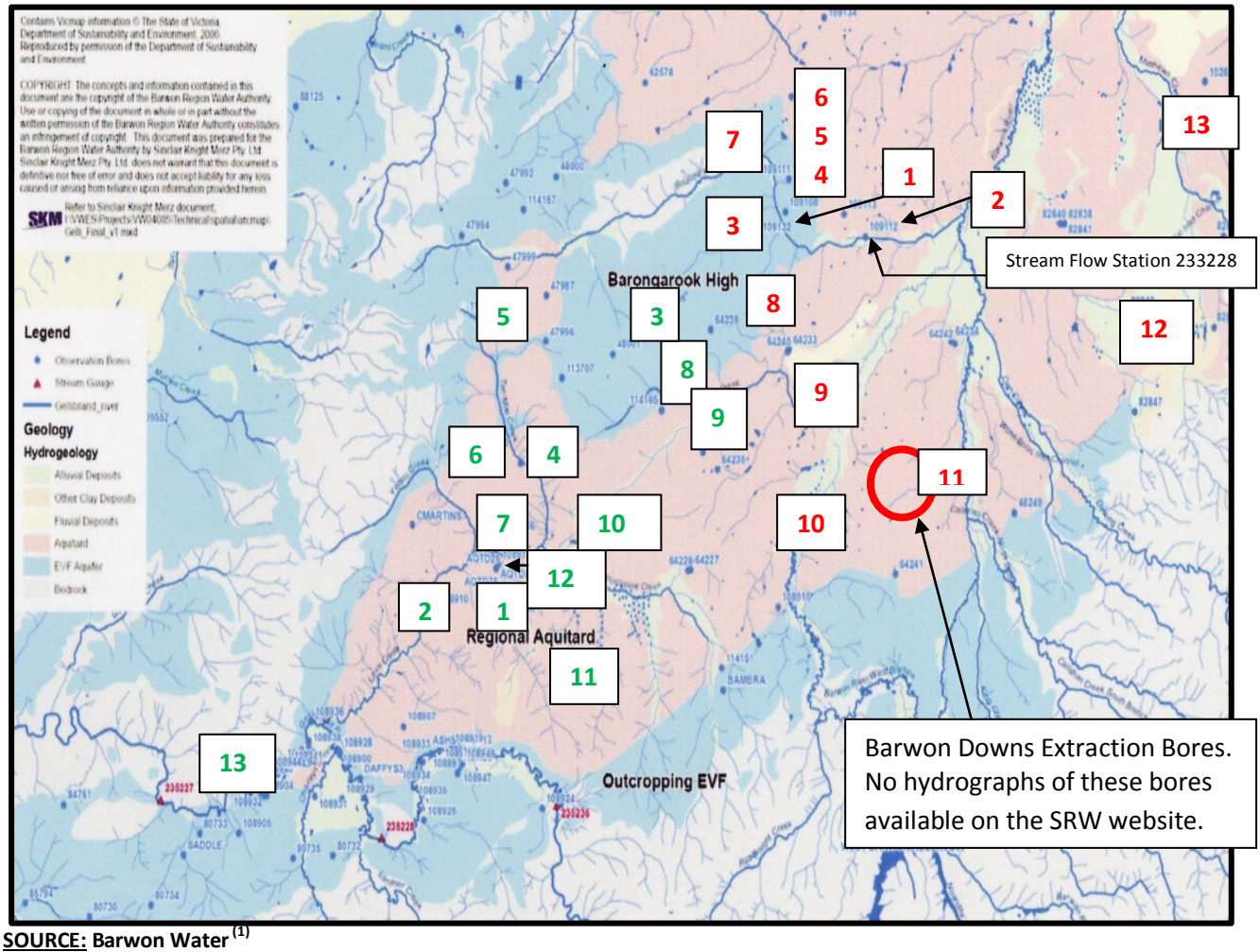
SOURCE: **Vic Water Data Warehouse & Barwon Water Annual reports.** **(Southern Rural Water does not provide a hydrograph of Yeo 40.)**



The water table in Yeo 40 was still below the 150 mAHD mark at 30 June 2012.

SOURCE: **Barwon Water 2008-09 Gerangamete Groundwater report.**

CHAPTER SEVEN
Hydrograph Locations.



SOURCE: Barwon Water [1]

Bore Locations.

1.Yeo 40(ID 109131) 2.Yeo 21(ID 109112) 3.Yeo 41(ID 109132) 4. Yeo 39(ID 109130)

5.Yeo 19(ID 109110) 6.Yeo 42(ID 109133) 7.Yeo 37(ID 109128) 8. ID 64239

9. G 14 (ID 64230) 10. G 21 (ID 64237) 11. ID 64241 12. ID 82843

13. W 7 (ID 102868).

1.ID 108913 2. ID 108910 3. ID 114166 4. ID 114168

5. ID 113705 6. ID 47990 7. 47986 8. ID 48001

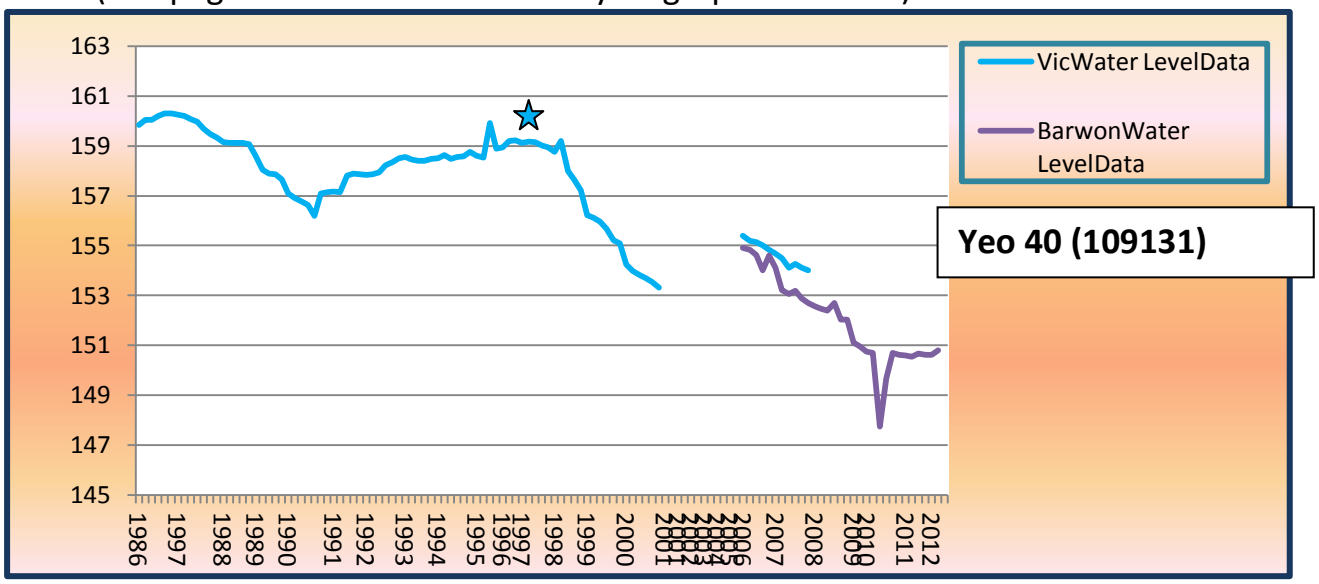
9. ID 114164 10. ID 48003 11. ID 108914 12. ID 108911

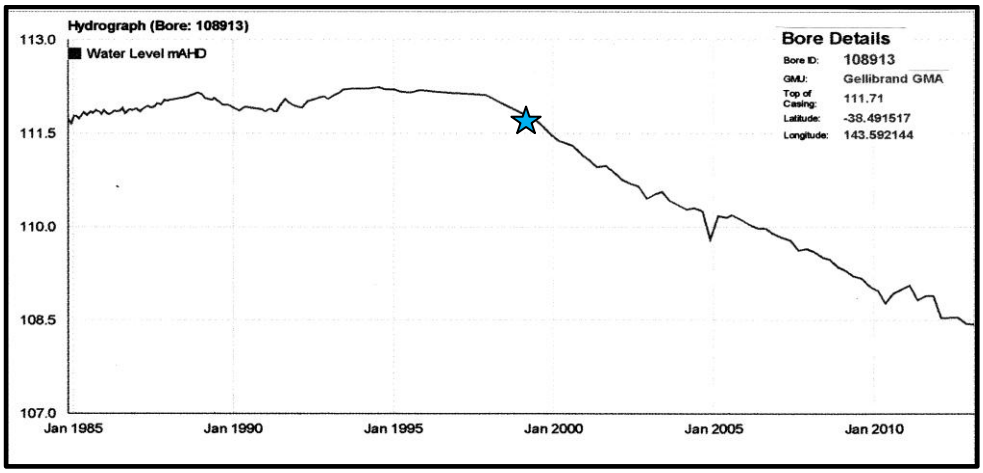
13. ID 108906.

CHAPTER EIGHT
Hydrograph Comparisons.

The hydrographs, except for Yeo 40, presented in this chapter have been copied from the Southern Rural Water website[11] for groundwater levels as at 3 April 2013 and have been reasonably and accurately represented to adequately demonstrate the comparison between the two areas studied.

1. (See pages 16 & 59 for another hydrograph of Yeo 40)





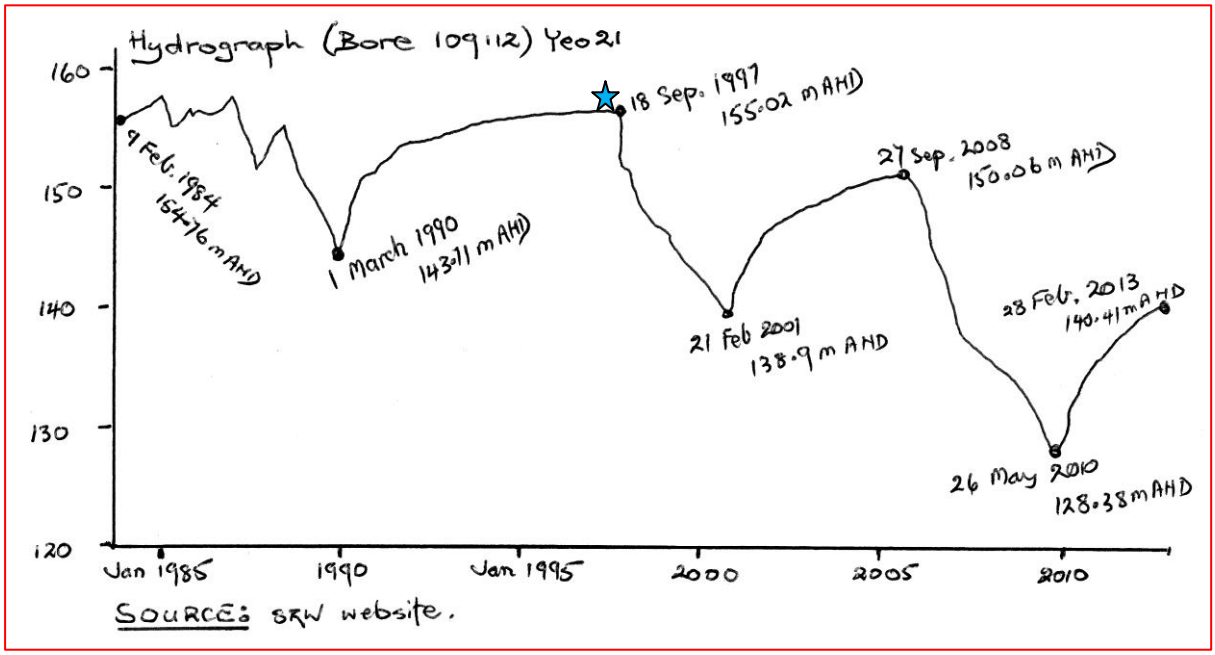
1.

The hydrographs numbered in **green** have been presented in two formats:

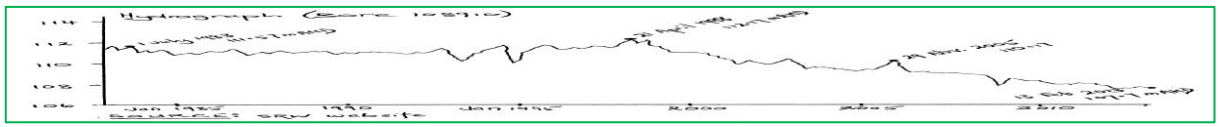
- **A.** Adjusted so that the vertical and horizontal scales are similar to the hydrographs numbered in **red**, and
- **B.** full size as printed from the Southern Rural Water website.

The blue stars ★ indicate the end of a very wet period and when there was no groundwater extraction, 1990-1997. Groundwater extraction at the Barwon Downs Borefield was halted August 2010.

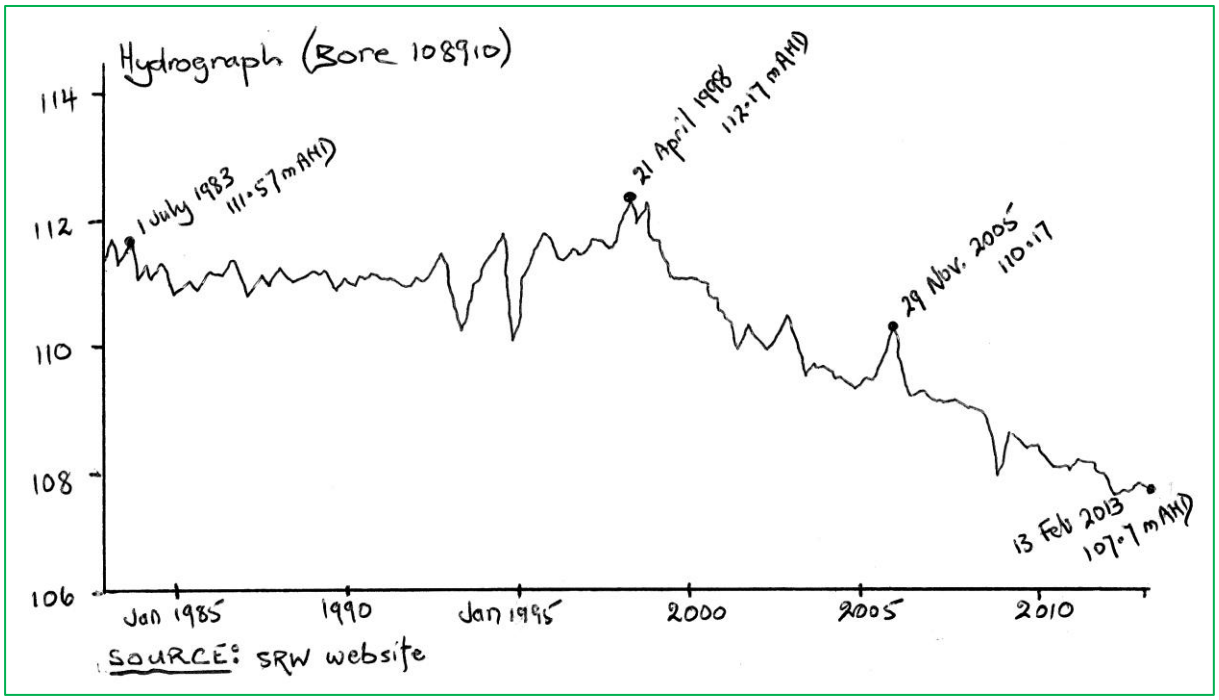
2.



2A.



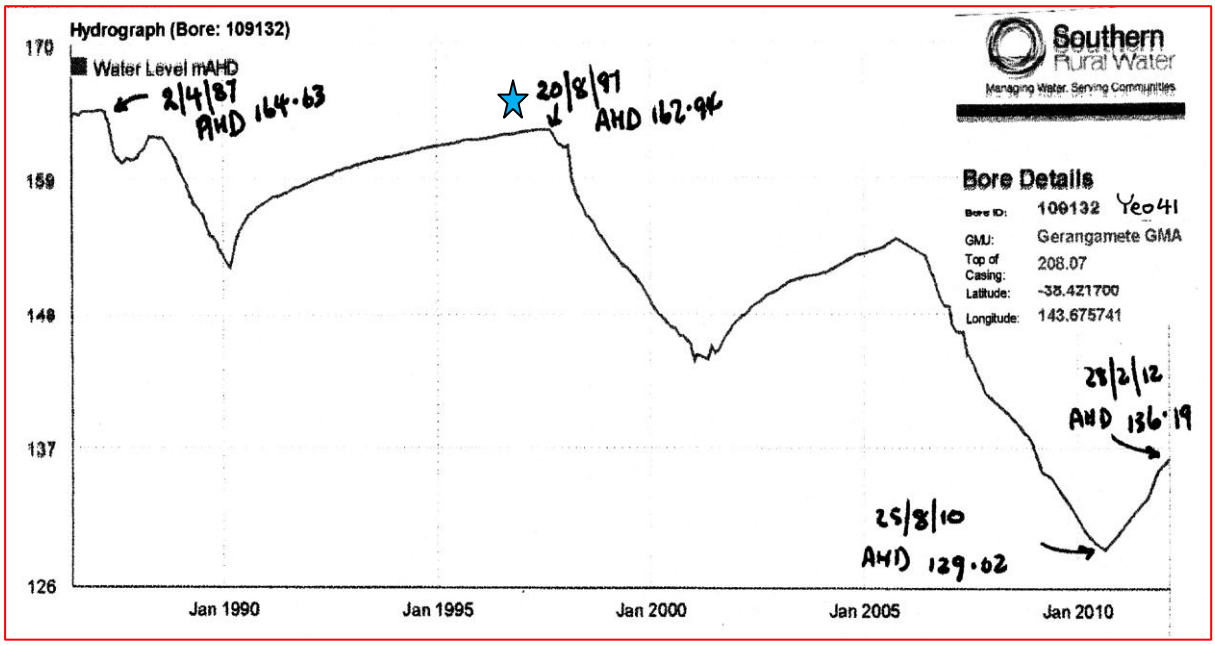
2B.



When using the same horizontal and vertical scale dimensions for graphs **2** & **2A** it is extremely obvious that the hydrograph for Bore 108910 is in gradual

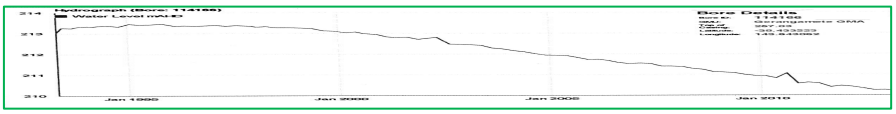
decline over the same time period and does not have the accentuated dips and highs of many metres as those bores directly influenced from the Borefield.

3.

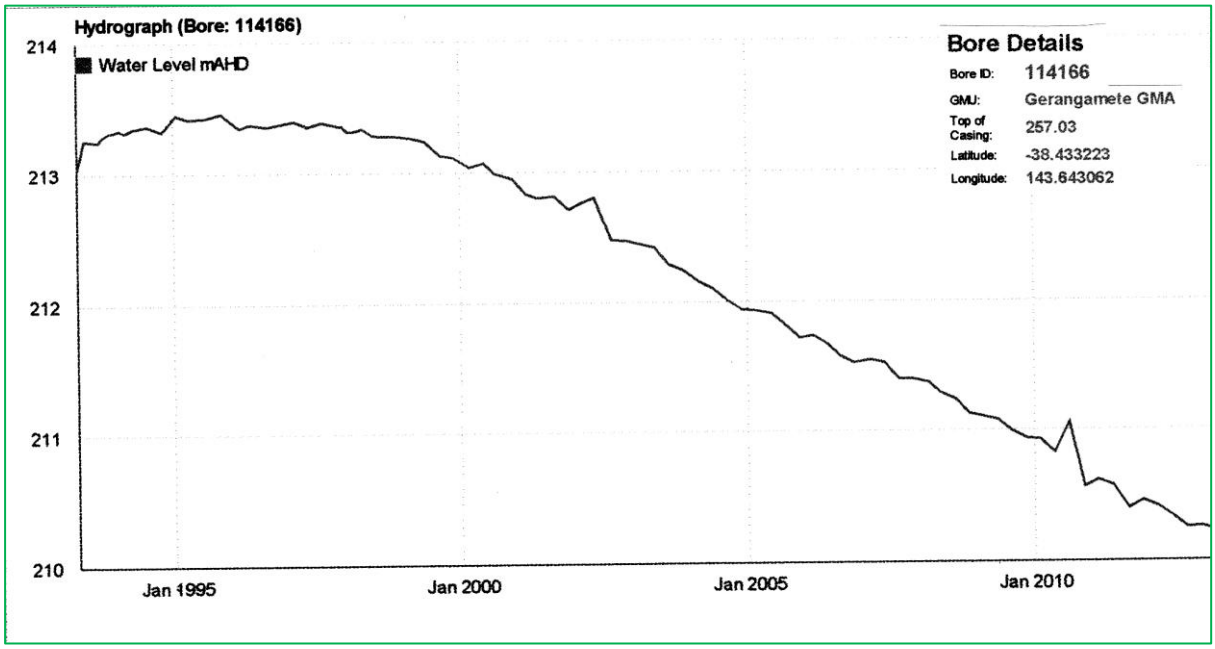


Throughout the area directly influenced from the Barwon Downs Borefield the observation bore hydrographs display this inverse response to groundwater extraction (see page 22).

3A.

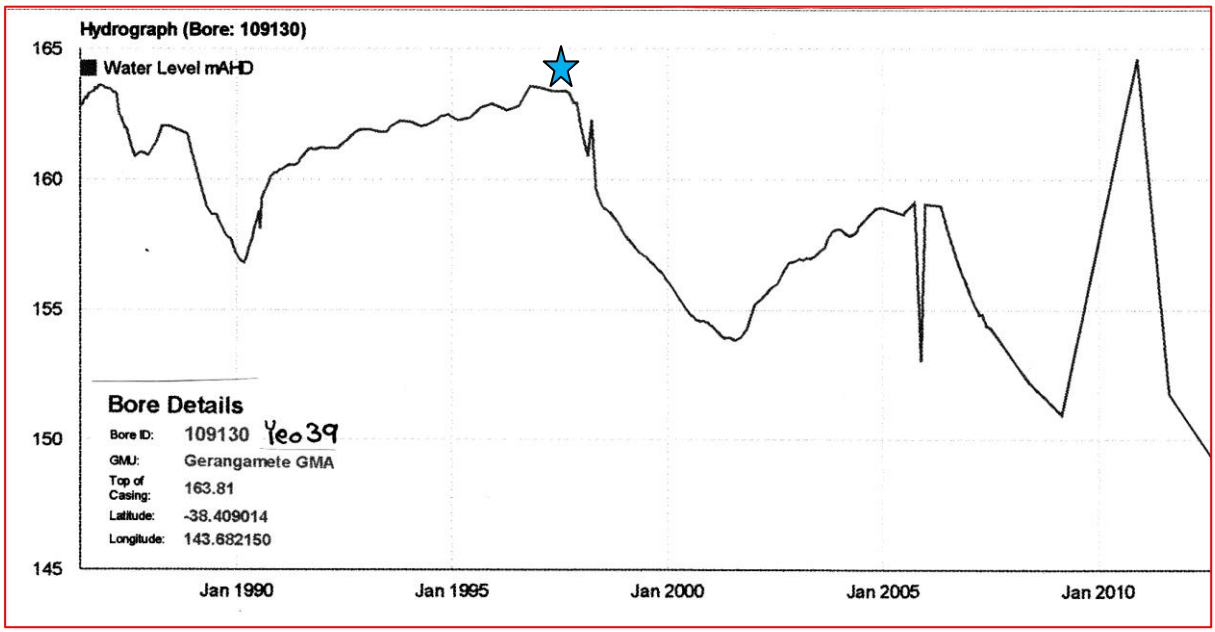


3B.

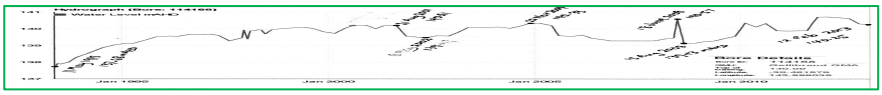


For those bores not directly influenced from the Borefield the hydrographs are gradual and of a significantly smaller degree of decline.

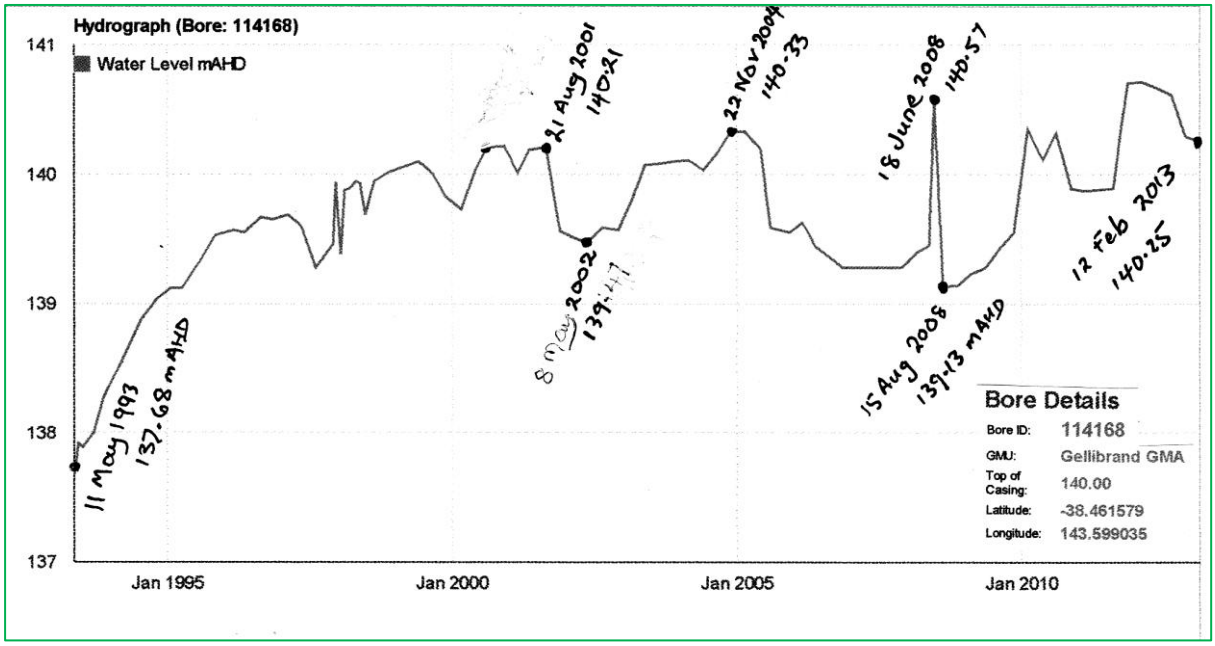
4.



4A.

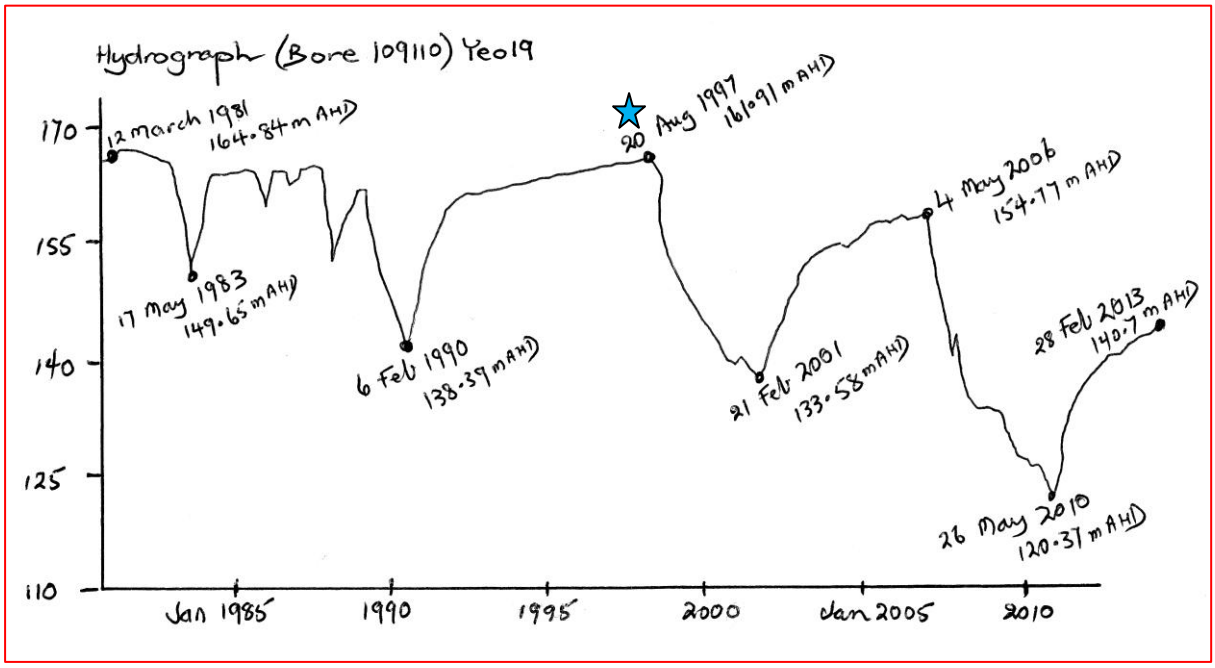


4B.



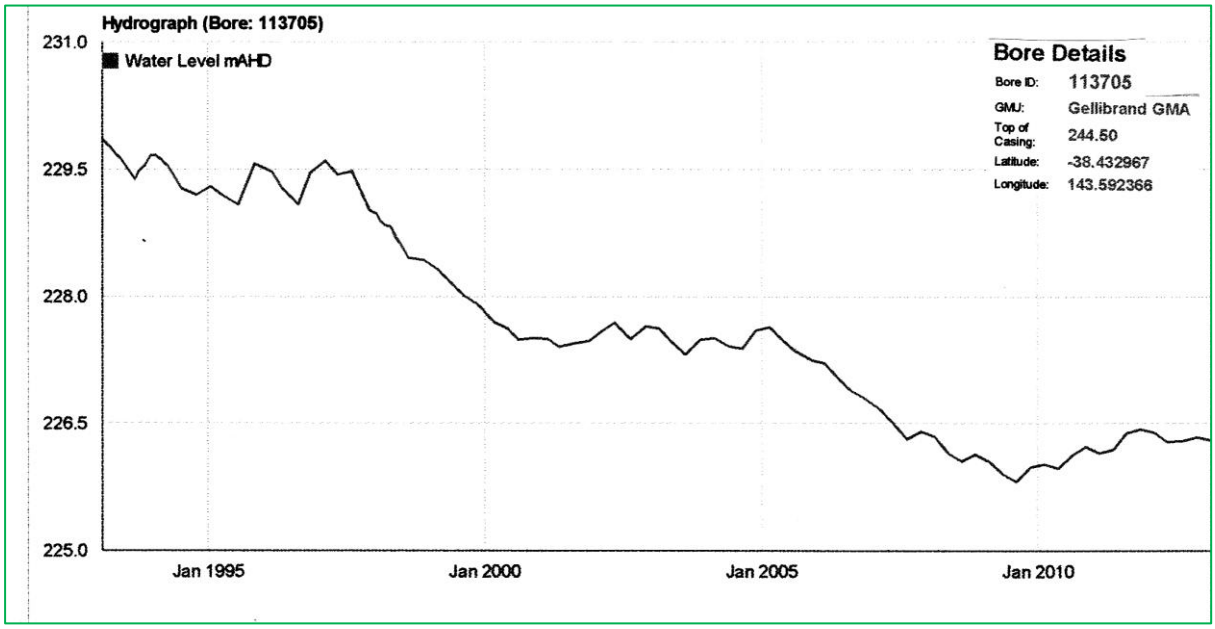
This particular observation bore is going against the trend and shows the water table to be gradually rising.

5.

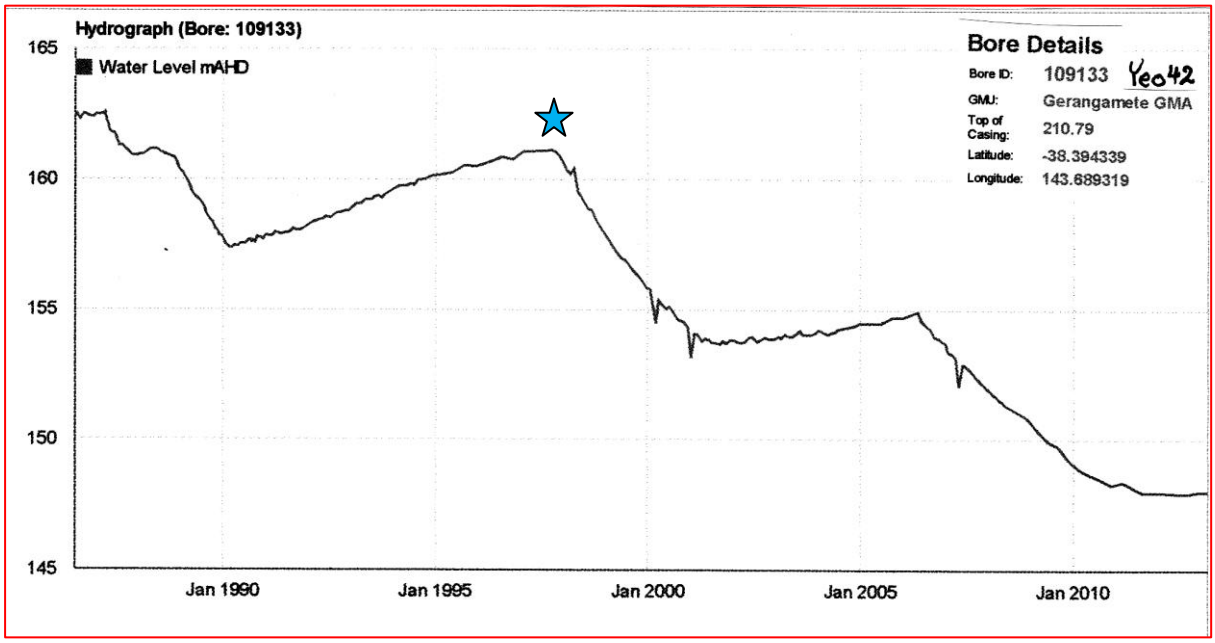

Hydrograph (Bore 109110) Yeo19
170
155
140
125
110
12 March 1981
164.84 m AHD
17 May 1983
149.65 m AHD
6 Feb 1990
138.39 m AHD
20 Aug 1997
161.91 m AHD
21 Feb 2001
133.58 m AHD
4 May 2006
154.77 m AHD
26 May 2010
120.37 m AHD
28 Feb 2013
140.7 m AHD
Jan 1985
1990
1995
2000
Jan 2005
2010

5A.

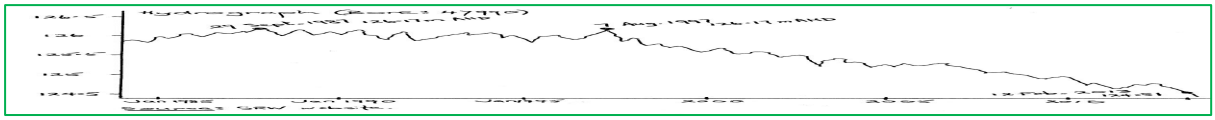
5B.


Hydrograph (Bore: 113705)
Water Level mAHD
231.0
229.5
228.0
226.5
225.0
Jan 1995
Jan 2000
Jan 2005
Jan 2010
Bore Details
Bore ID: 113705
GMU: Gellibrand GMA
Top of Casing: 244.50
Latitude: -38.432967
Longitude: 143.592366

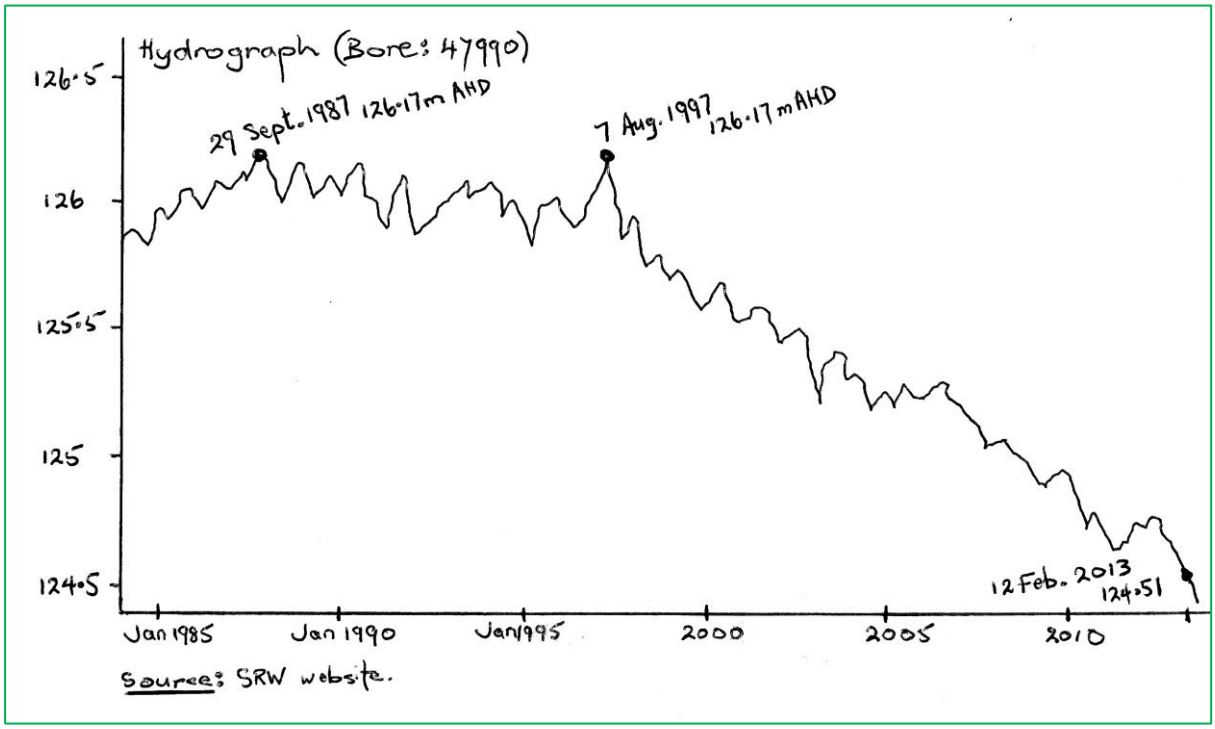
6.


Hydrograph (Bore: 109133)
Water Level mAHD
165
160
155
150
145
Jan 1990
Jan 1995
Jan 2000
Jan 2005
Jan 2010
Bore Details
Bore ID: 109133 Yeo42
GMU: Gerangamete GMA
Top of Casing: 210.79
Latitude: -38.394339
Longitude: 143.689319

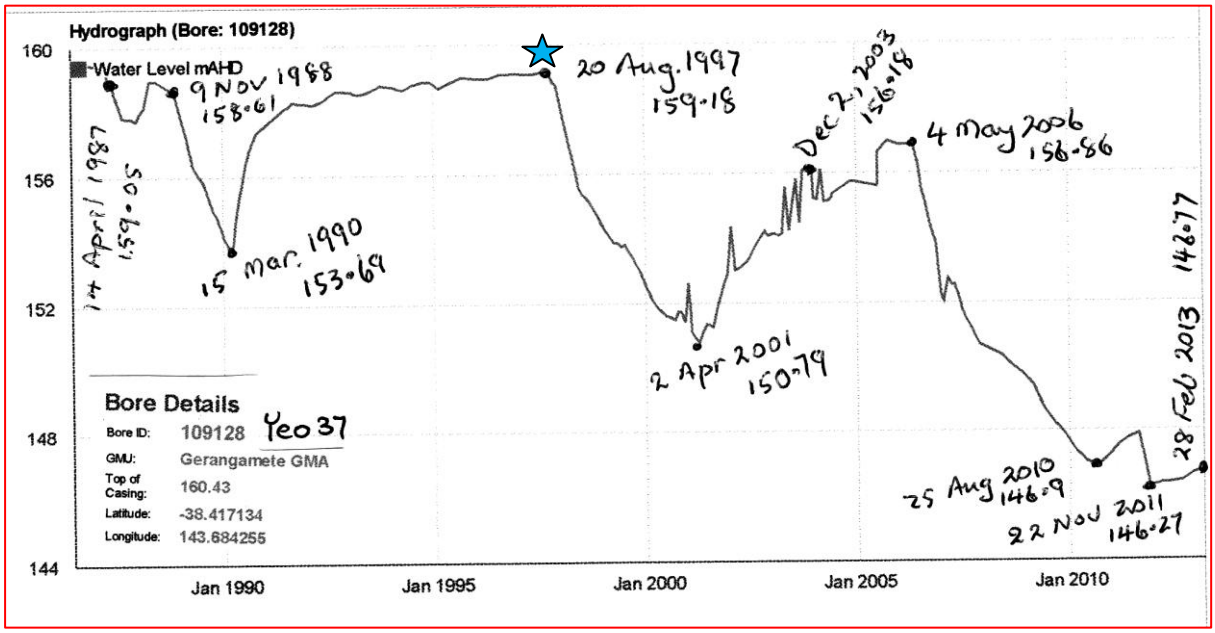
6A.



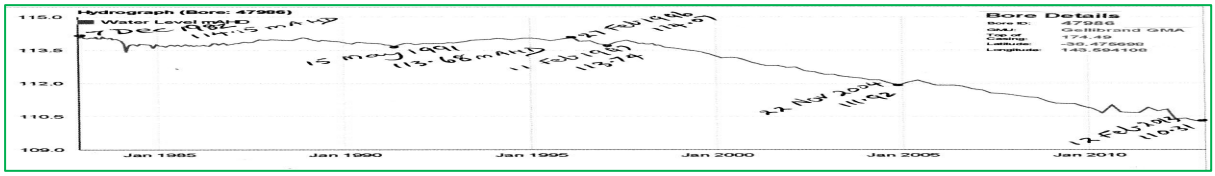
6B.


Hydrograph (Bore: 47990)
29 Sept. 1987 126·17m AHD
7 Aug. 1997 126·17m AHD
12 Feb. 2013 124·51
126·5
126
125·5
125
124·5
Jan 1985
Jan 1990
Jan 1995
2000
2005
2010
Source: SRW website.

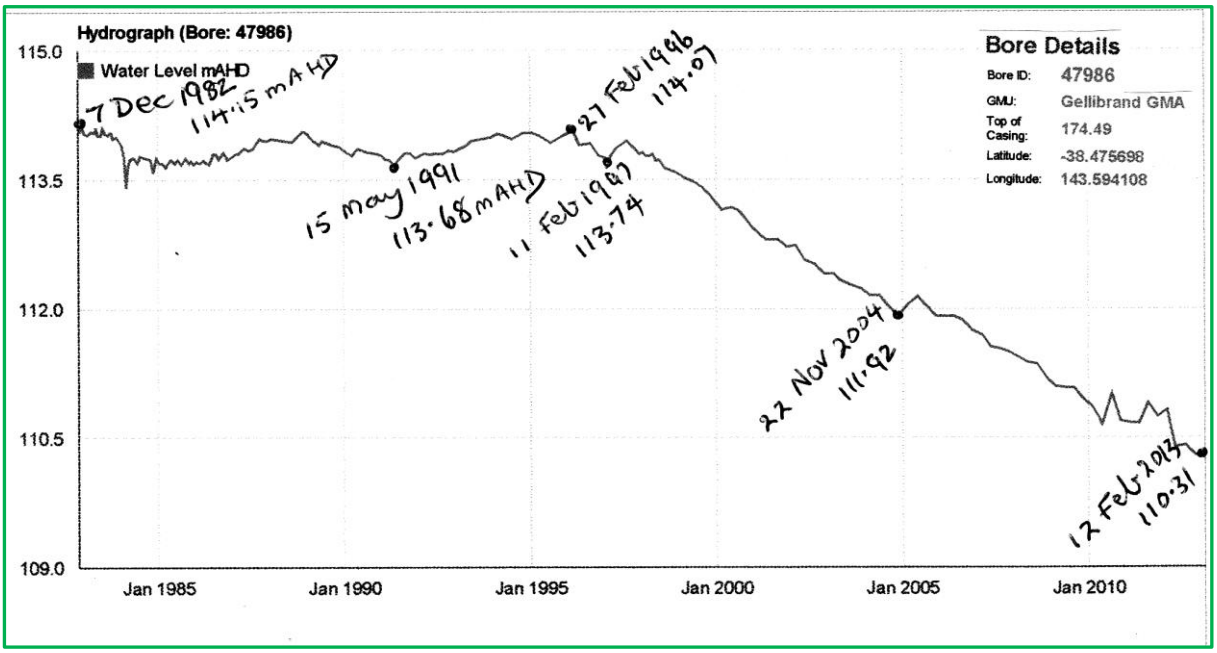
7.


Hydrograph (Bore: 109128)
Water Level mAHD
160
156
152
148
144
Jan 1990
Jan 1995
Jan 2000
Jan 2005
Jan 2010
14 April 1987 159.05
9 Nov 1988 158.61
15 Mar. 1990 153.69
20 Aug. 1997 159.18
2 Apr 2001 150.79
Dec 2, 2003 156.18
4 May 2006 158.86
25 Aug 2010 146.9
22 Nov 2011 146.27
28 Feb 2013 148.77
Bore Details
Bore ID: 109128 Yeo 37
GMU: Gerangamete GMA
Top of Casing: 160.43
Latitude: -38.417134
Longitude: 143.684255

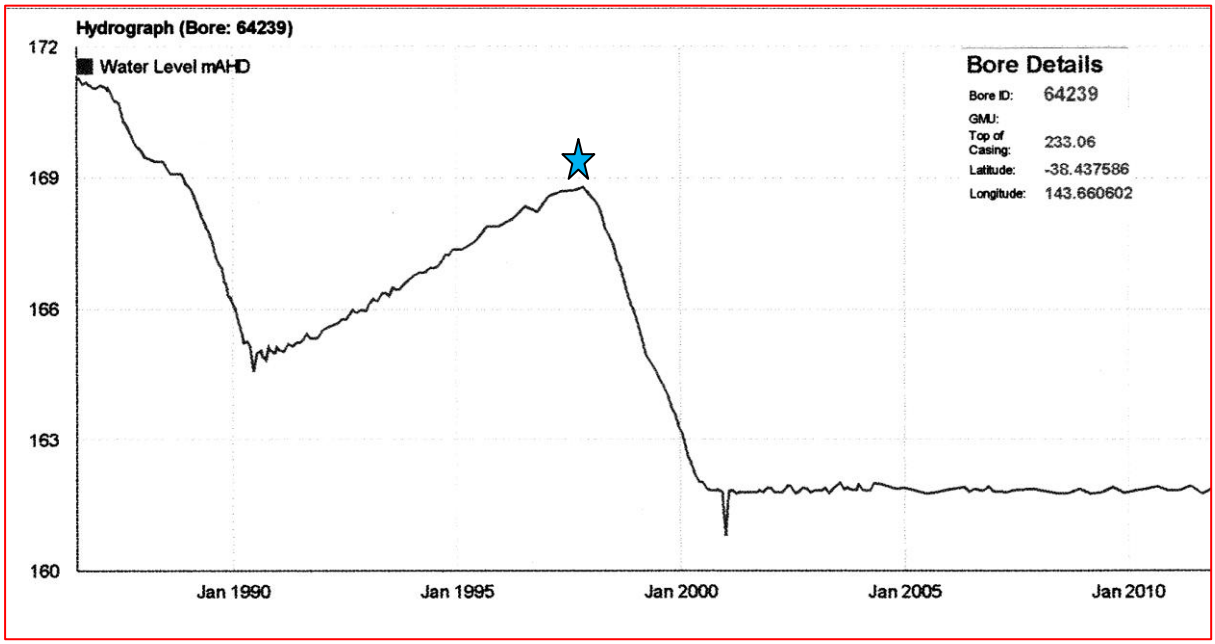
7A.


Hydrograph (Bore: 47986)
Water Level mAHD
7 Dec 1982 114.15 mAHD
15 May 1991 113.68 mAHD
11 Feb 1997 113.74
27 Feb 1996 114.07
22 Nov 2004 111.92
12 Feb 2012 110.31
Bore Details
Bore ID: 47986
GMU: Gellibrand GMA
Top of Casing: 174.49
Latitude: -38.475698
Longitude: 143.594108

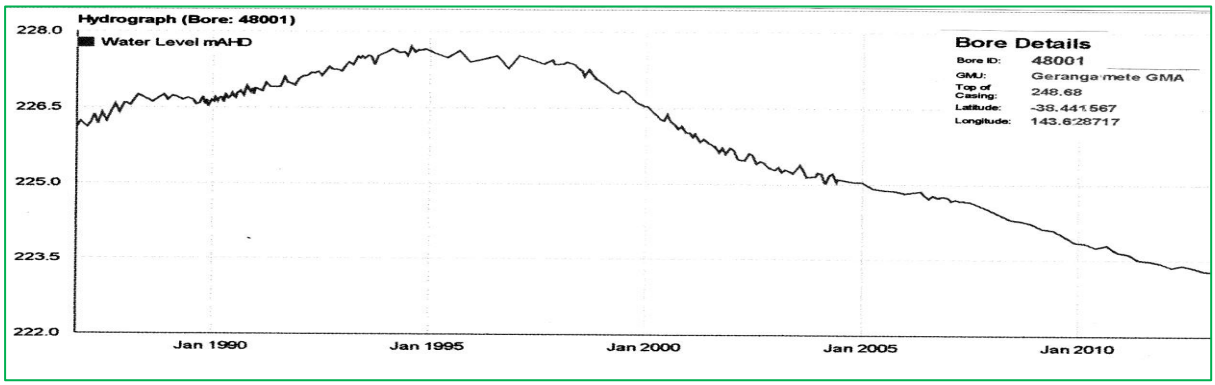
7B.


Hydrograph (Bore: 47986)
Water Level mAHD
115.0
113.5
112.0
110.5
109.0
Jan 1985
Jan 1990
Jan 1995
Jan 2000
Jan 2005
Jan 2010
7 Dec 1982 114.15 mAHD
15 May 1991 113.68 mAHD
11 Feb 1997 113.74
27 Feb 1996 114.07
22 Nov 2004 111.92
12 Feb 2012 110.31
Bore Details
Bore ID: 47986
GMU: Gellibrand GMA
Top of Casing: 174.49
Latitude: -38.475698
Longitude: 143.594108

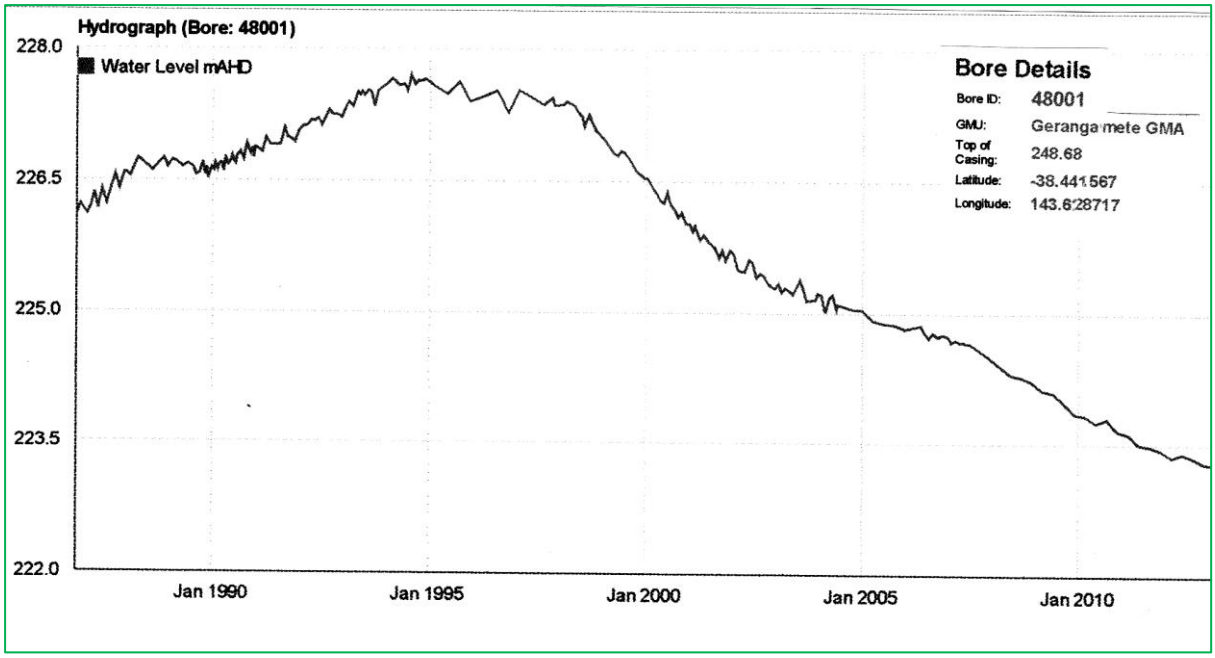
8.


Hydrograph (Bore: 64239)
Water Level mAHD
172
169
166
163
160
Jan 1990
Jan 1995
Jan 2000
Jan 2005
Jan 2010
Bore Details
Bore ID: 64239
GMU:
Top of Casing: 233.06
Latitude: -38.437586
Longitude: 143.660602

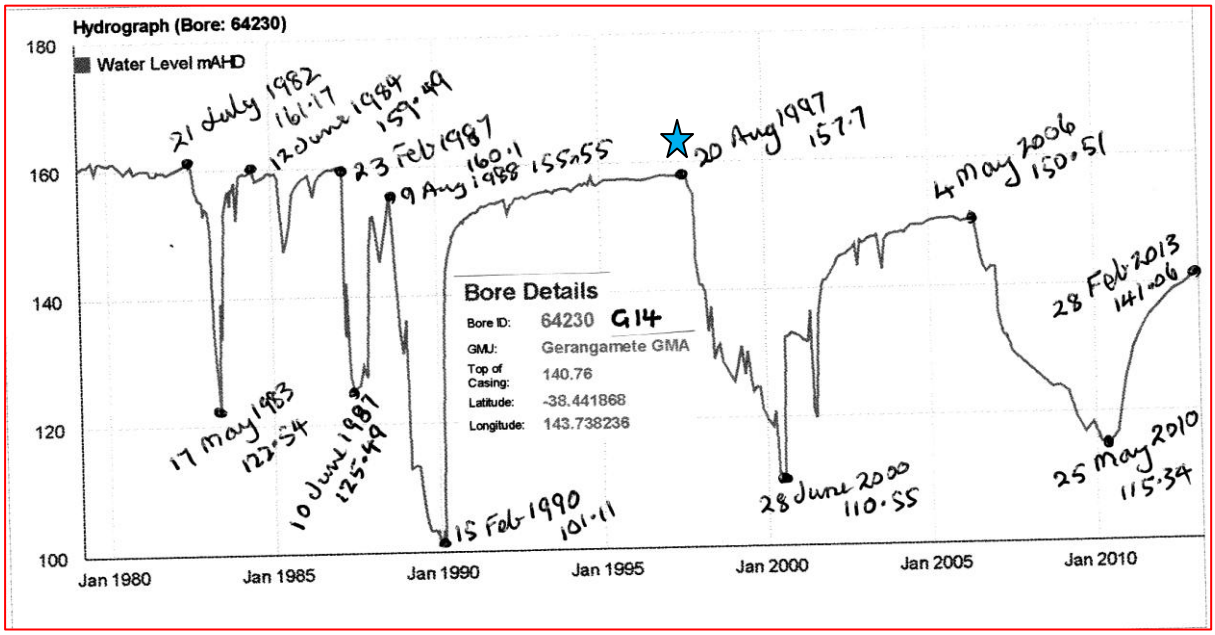
8A.


Hydrograph (Bore: 48001)
Water Level mAHD
228.0
226.5
225.0
223.5
222.0
Jan 1990
Jan 1995
Jan 2000
Jan 2005
Jan 2010
Bore Details
Bore ID: 48001
GMU: Geranga mete GMA
Top of Casing: 248.68
Latitude: -38.441567
Longitude: 143.628717

8B.

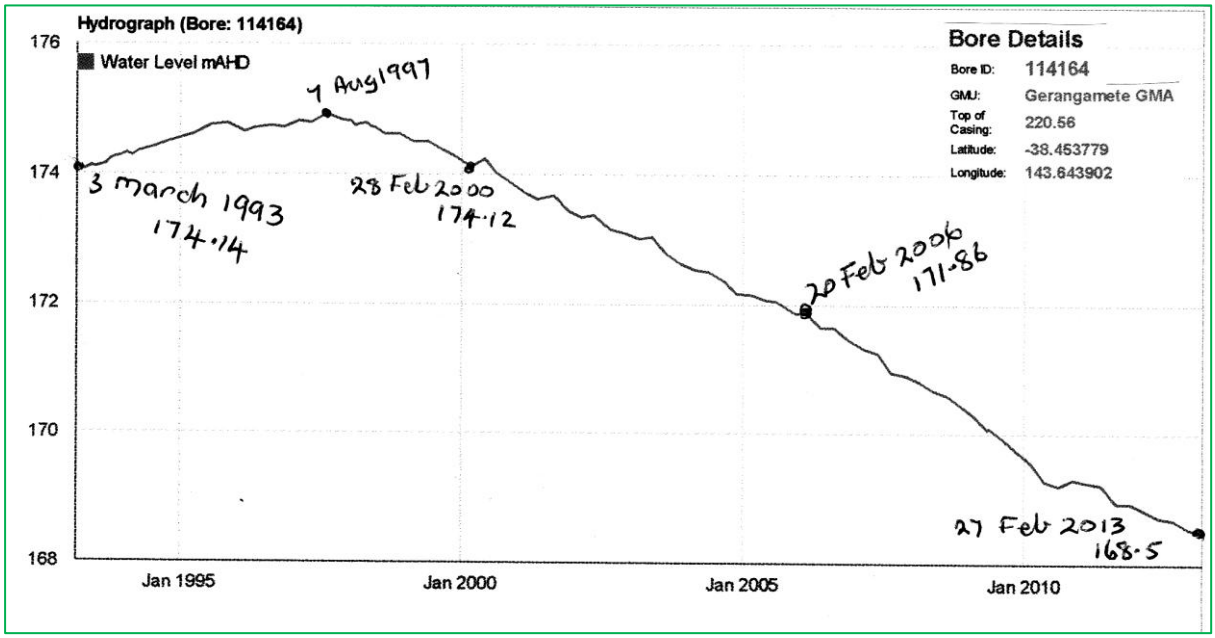

Hydrograph (Bore: 48001)
Water Level mAHD
228.0
226.5
225.0
223.5
222.0
Jan 1990
Jan 1995
Jan 2000
Jan 2005
Jan 2010
Bore Details
Bore ID: 48001
GMU: Geranga mete GMA
Top of Casing: 248.68
Latitude: -38.441567
Longitude: 143.628717

9.

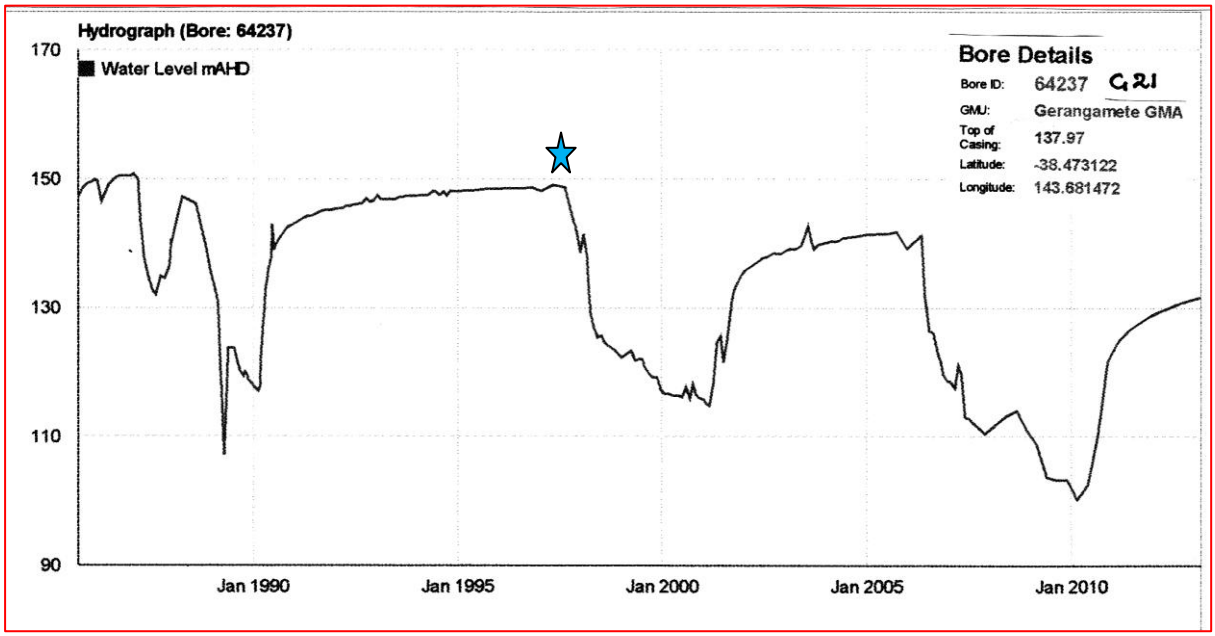

Hydrograph (Bore: 64230)
Water Level mAHD
180
160
140
120
100
Jan 1980
Jan 1985
Jan 1990
Jan 1995
Jan 2000
Jan 2005
Jan 2010
21 July 1982 161.17
12 June 1984 159.49
23 Feb 1987 160.1
9 Aug 1988 155.55
20 Aug 1997 157.7
4 May 2006 150.51
28 Feb 2013 141.06
17 May 1983 122.34
10 June 1987 125.49
15 Feb 1990 101.11
28 June 2000 110.55
25 May 2010 115.34
Bore Details
Bore ID: 64230 G14
GMU: Gerangamete GMA
Top of Casing: 140.76
Latitude: -38.441868
Longitude: 143.738236

9A.

9B.

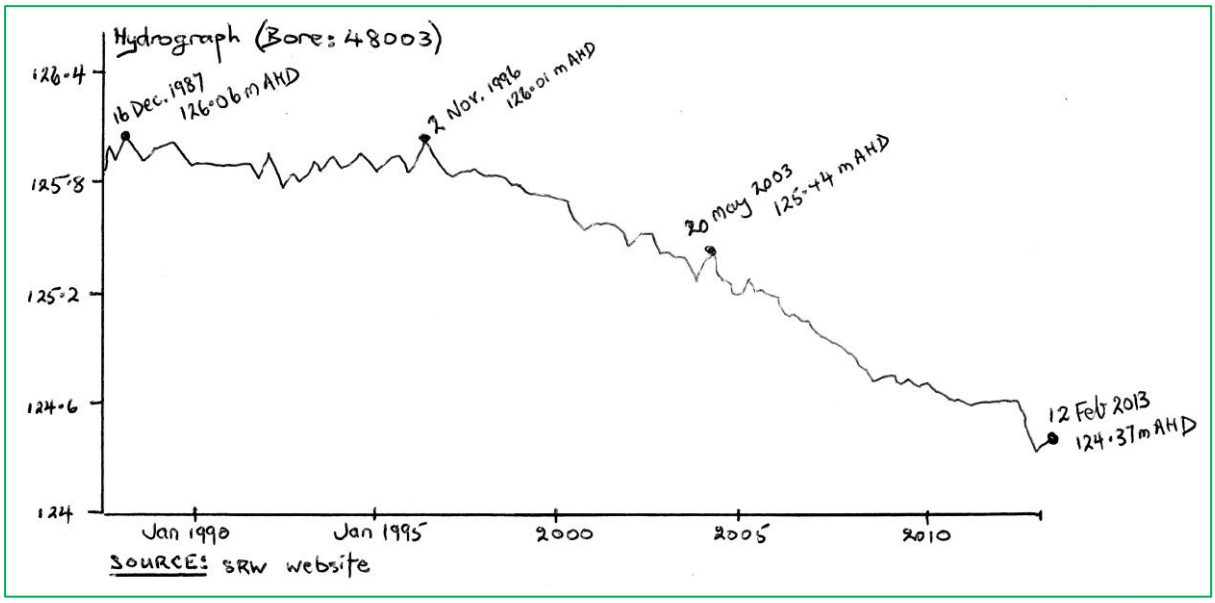

Hydrograph (Bore: 114164)
Water Level mAHD
176
174
172
170
168
Jan 1995
Jan 2000
Jan 2005
Jan 2010
7 Aug 1997
3 March 1993 174.14
28 Feb 2000 174.12
20 Feb 2006 171.86
27 Feb 2013 168.5
Bore Details
Bore ID: 114164
GMU: Gerangamete GMA
Top of Casing: 220.56
Latitude: -38.453779
Longitude: 143.643902

10.

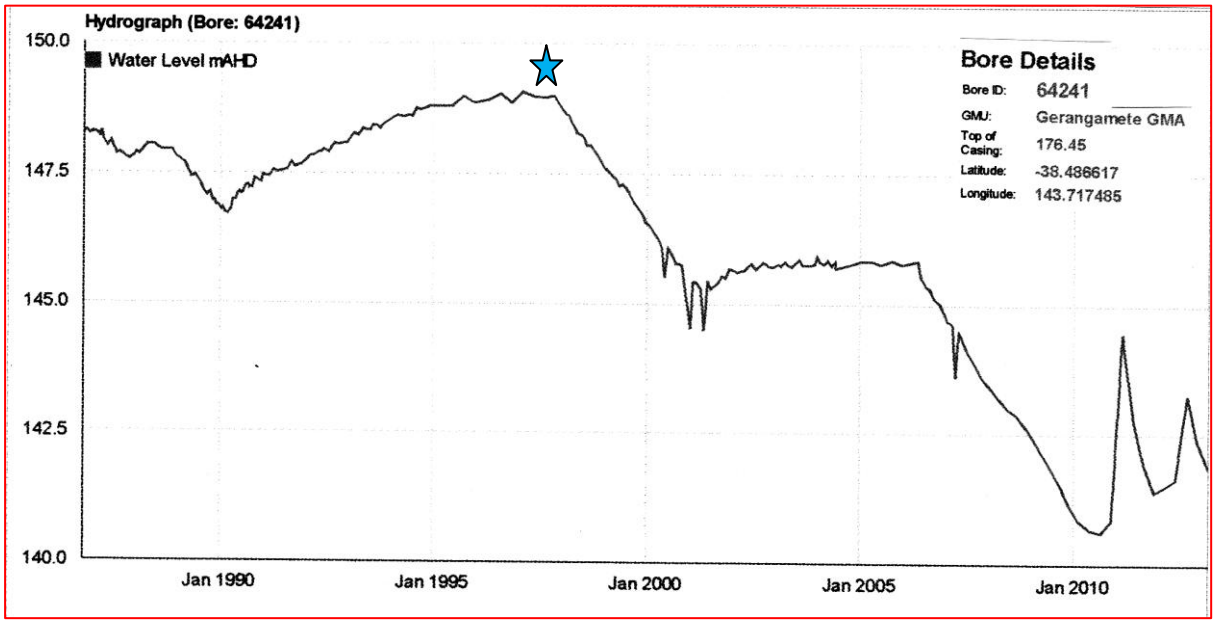

Hydrograph (Bore: 64237)
Water Level mAHD
170
150
130
110
90
Jan 1990
Jan 1995
Jan 2000
Jan 2005
Jan 2010
Bore Details
Bore ID: 64237 G21
GMU: Gerangamete GMA
Top of Casing: 137.97
Latitude: -38.473122
Longitude: 143.681472

10A.

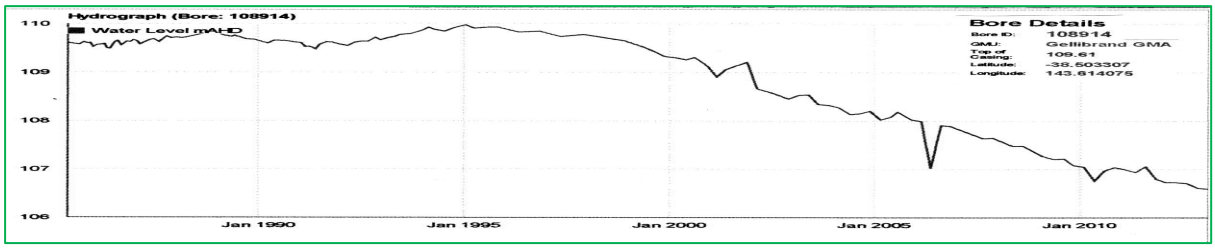
10B.


Hydrograph (Bore: 48003)
126·4
125·8
125·2
124·6
124
16 Dec. 1987
126·06 m AHD
2 Nov. 1996
126·01 m AHD
20 May 2003
125·44 m AHD
12 Feb 2013
124·37 m AHD
Jan 1990
Jan 1995
2000
2005
2010
SOURCE: SRW website

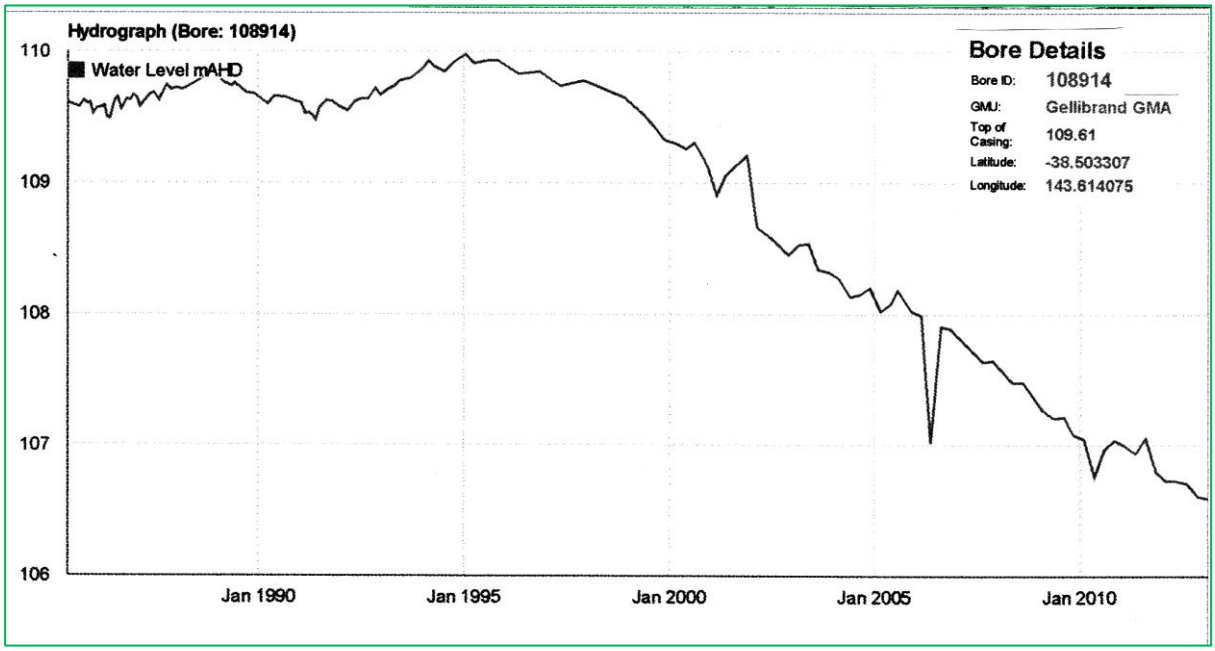
11.


Hydrograph (Bore: 64241)
Water Level mAHD
150.0
147.5
145.0
142.5
140.0
Jan 1990
Jan 1995
Jan 2000
Jan 2005
Jan 2010
Bore Details
Bore ID: 64241
GMU: Gerangamete GMA
Top of Casing: 176.45
Latitude: -38.486617
Longitude: 143.717485

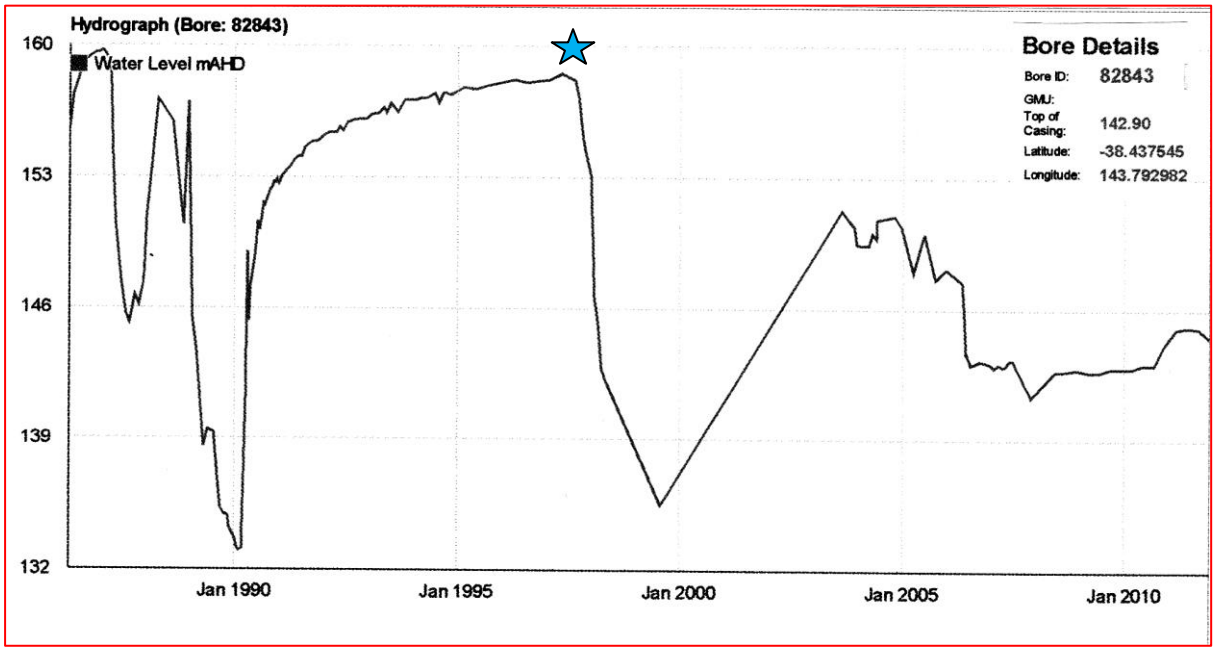
11A.


Hydrograph (Bore: 108914)
Water Level mAHD
110
109
108
107
106
Jan 1990
Jan 1995
Jan 2000
Jan 2005
Jan 2010
Bore Details
Bore ID: 108914
GMU: Gellibrand GMA
Top of Casing: 109.61
Latitude: -38.503307
Longitude: 143.614075

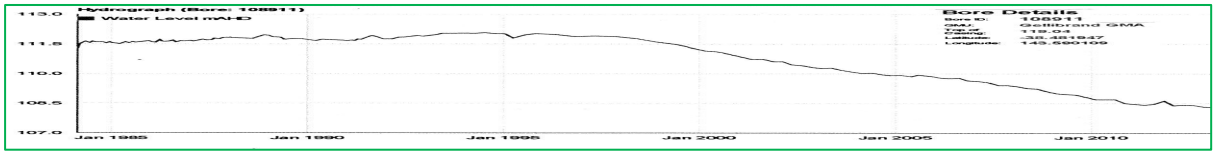
11B.


Hydrograph (Bore: 108914)
Water Level mAHD
110
109
108
107
106
Jan 1990
Jan 1995
Jan 2000
Jan 2005
Jan 2010
Bore Details
Bore ID: 108914
GMU: Gellibrand GMA
Top of Casing: 109.61
Latitude: -38.503307
Longitude: 143.614075

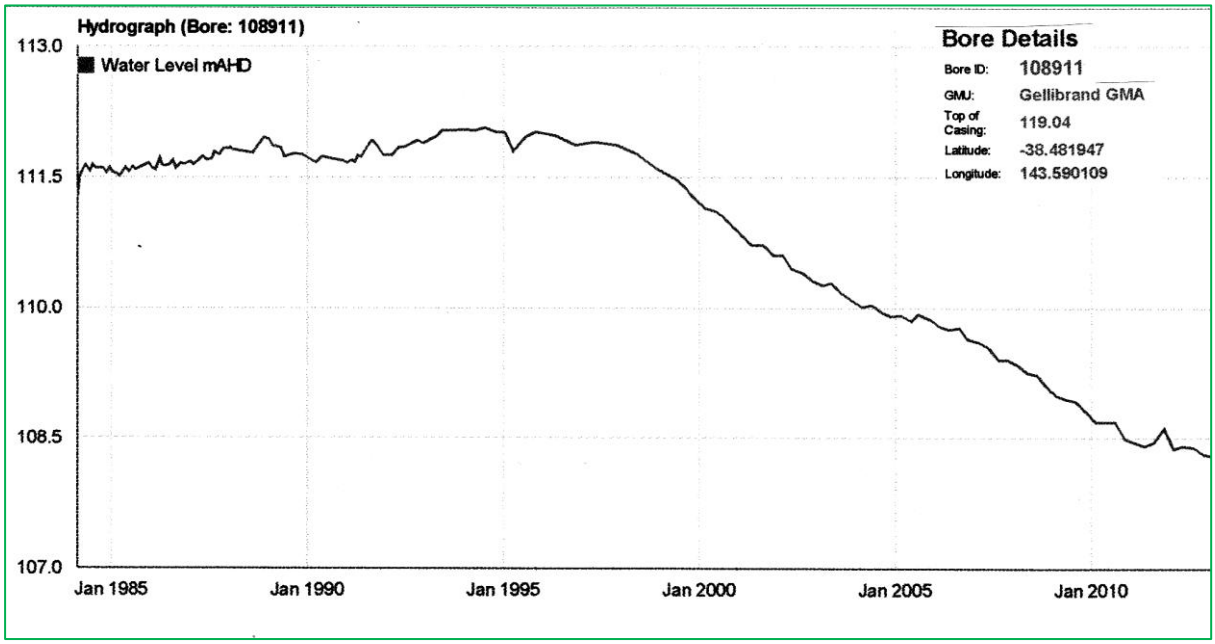
12.


Hydrograph (Bore: 82843)
Water Level mAHD
160
153
146
139
132
Jan 1990
Jan 1995
Jan 2000
Jan 2005
Jan 2010
Bore Details
Bore ID: 82843
GMU:
Top of Casing: 142.90
Latitude: -38.437545
Longitude: 143.792982

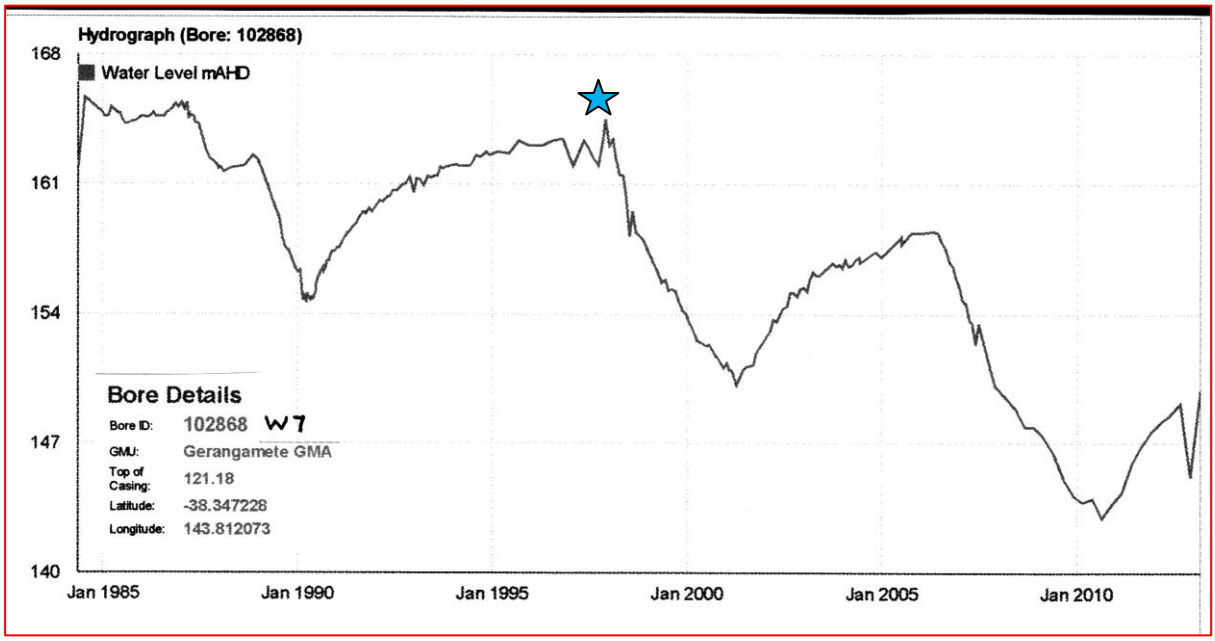
12A.



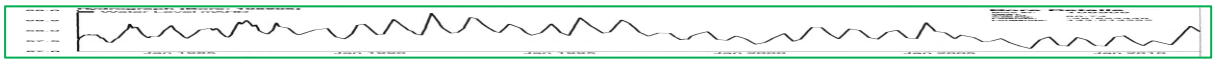
12B.


Hydrograph (Bore: 108911)
Water Level mAHD
113.0
111.5
110.0
108.5
107.0
Jan 1985
Jan 1990
Jan 1995
Jan 2000
Jan 2005
Jan 2010
Bore Details
Bore ID: 108911
GMU: Gellibrand GMA
Top of Casing: 119.04
Latitude: -38.481947
Longitude: 143.590109

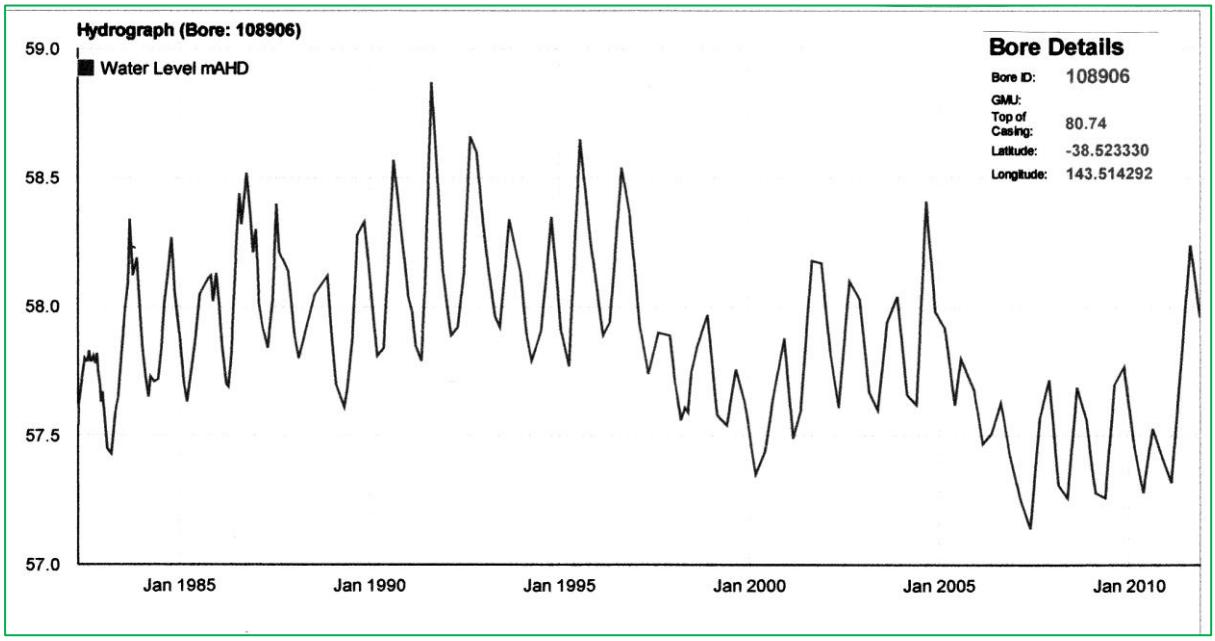
13.



13A.



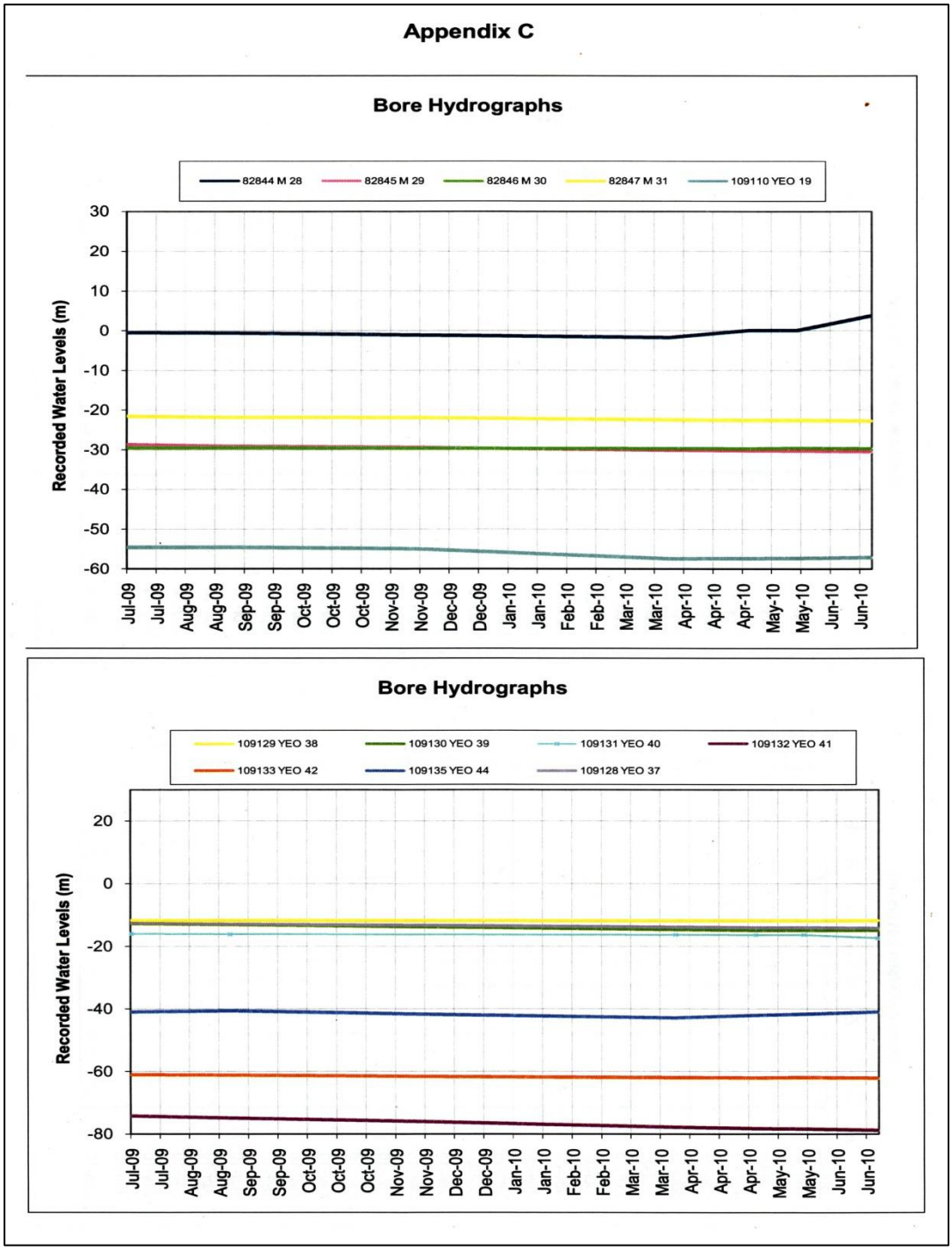
13B.



The dissimilar manner of the two sets of graphs in this chapter are even more intriguing when considering that the Kawarren/Gellibrand section of the EVF is normally recharged from rain falling on 10-12 km^2 of the Barongarook High sands (see page 27) and yet these hydrographs continue to fall. After three reasonably wet winters one would expect the hydrographs for the Kawarren/Gellibrand EVF to begin to rise. (See pages 52-55 for additional hydrographs, AppendixThree)

CHAPTER NINE
Gobble-de-Gook.

This page has been copied from the 2009-2010 report sent to Southern Rural Water reporting on the Barwon Downs Borefield. Note the relatively flat hydrographs.



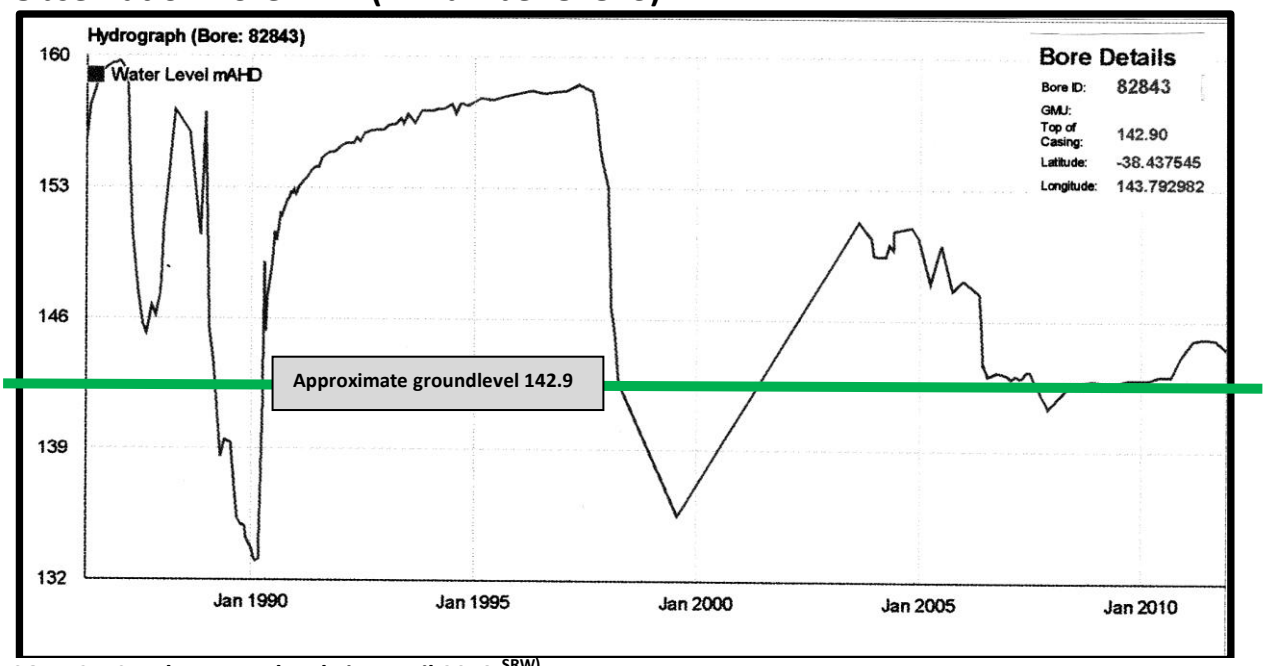
SOURCE: Barwon Water Report sent to Southern Rural Water on the Gerangamete Groundwater, 2009-10.

These hydrographs of the water table levels that are documented in the Barwon Water reports to Southern Rural Water may satisfy the conditions of the licence issued by Southern Rural Water, but they create a perception that there is little response to groundwater extraction. In many respect the hydrographs presented are all but impossible to make much sense of.

1. The number of bores represented on each graph varies from year to year, attempting to follow any particular bore's hydrograph requires considerable patience.
2. The changing colour for a particular bore from year to year is very confusing.
3. The scale for the "Recorded Water Level" varies.
4. What this scale actually represents has not been defined.
5. If "zero" represents groundlevel little sense as far as comparison between hydrographs can be made as each bore has a different starting groundlevel point.
6. The actual size of the graphs in the original reports are so small that lines and colours can sometimes be confused.
7. The general straightness of the majority of graphs gives the impression that there is very little change from year to year.

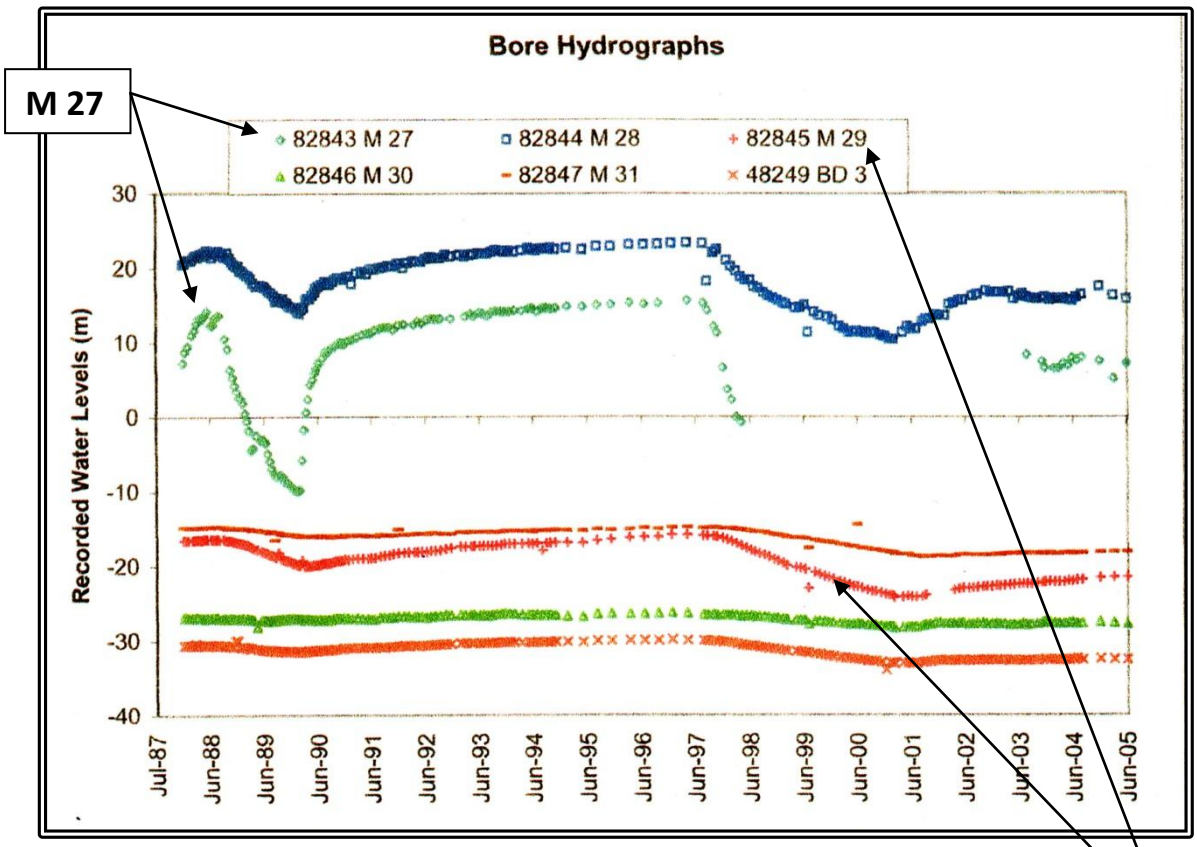
The Southern Rural Water hydrograph below shows this impression to be extremely misleading when compared with the Barwon Water reports.

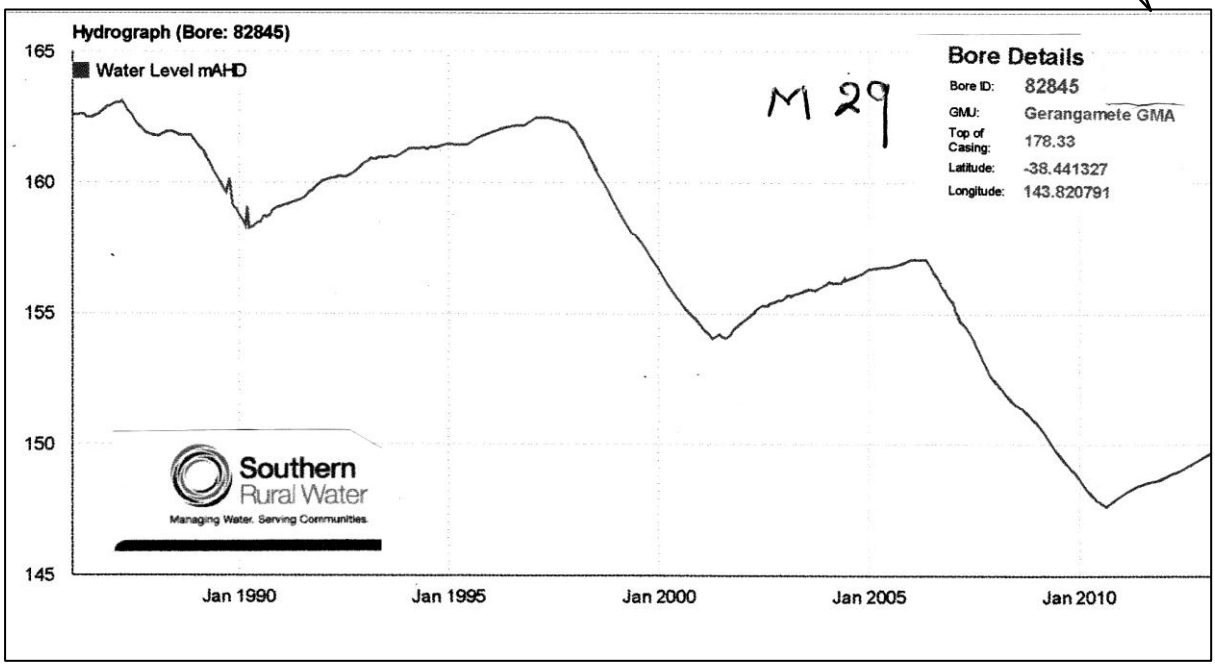
Observation Bore M27 (ID number 84843)

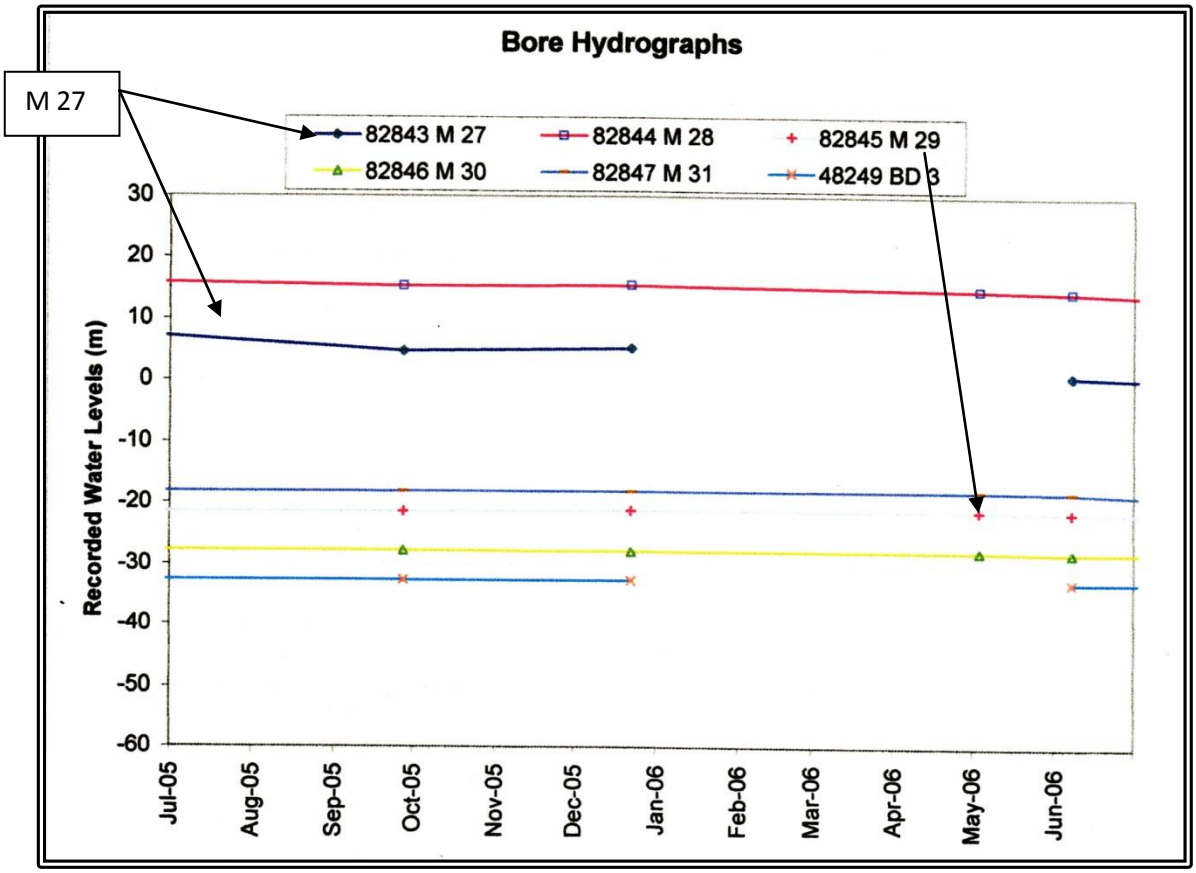


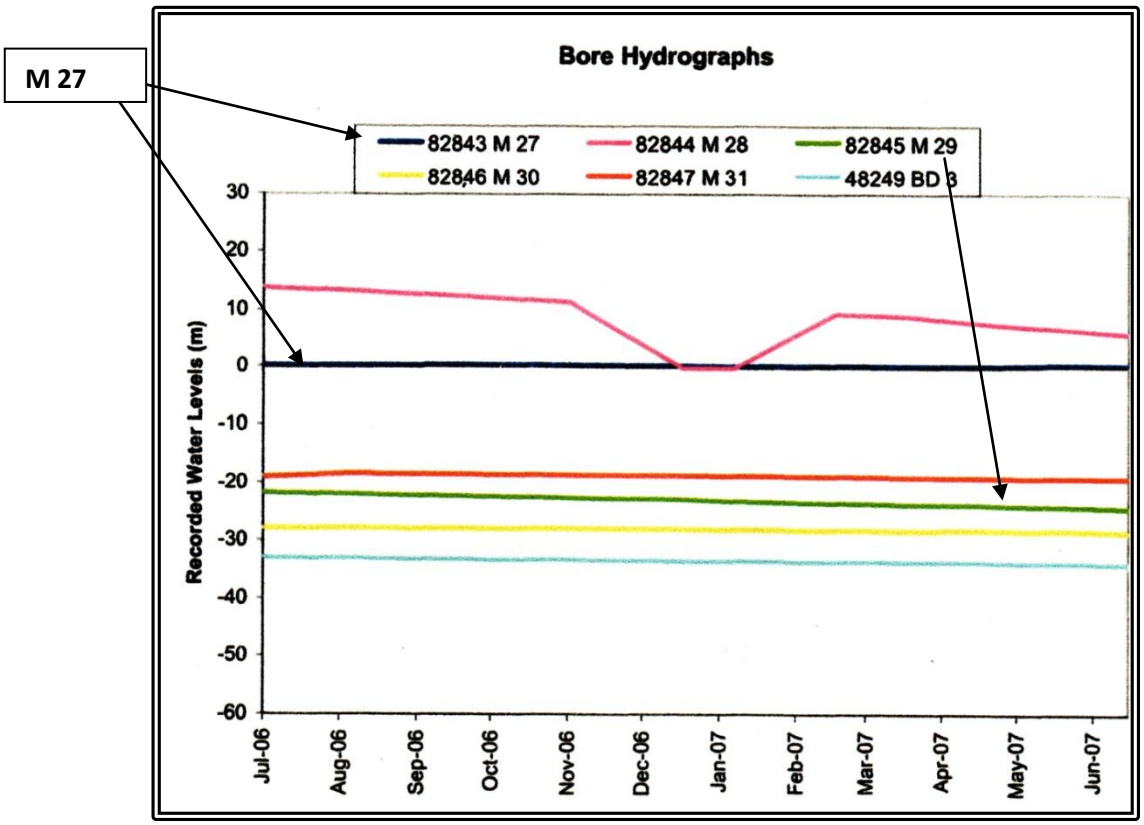
SOURCE: Southern Rural website April 2013.[SRW)]

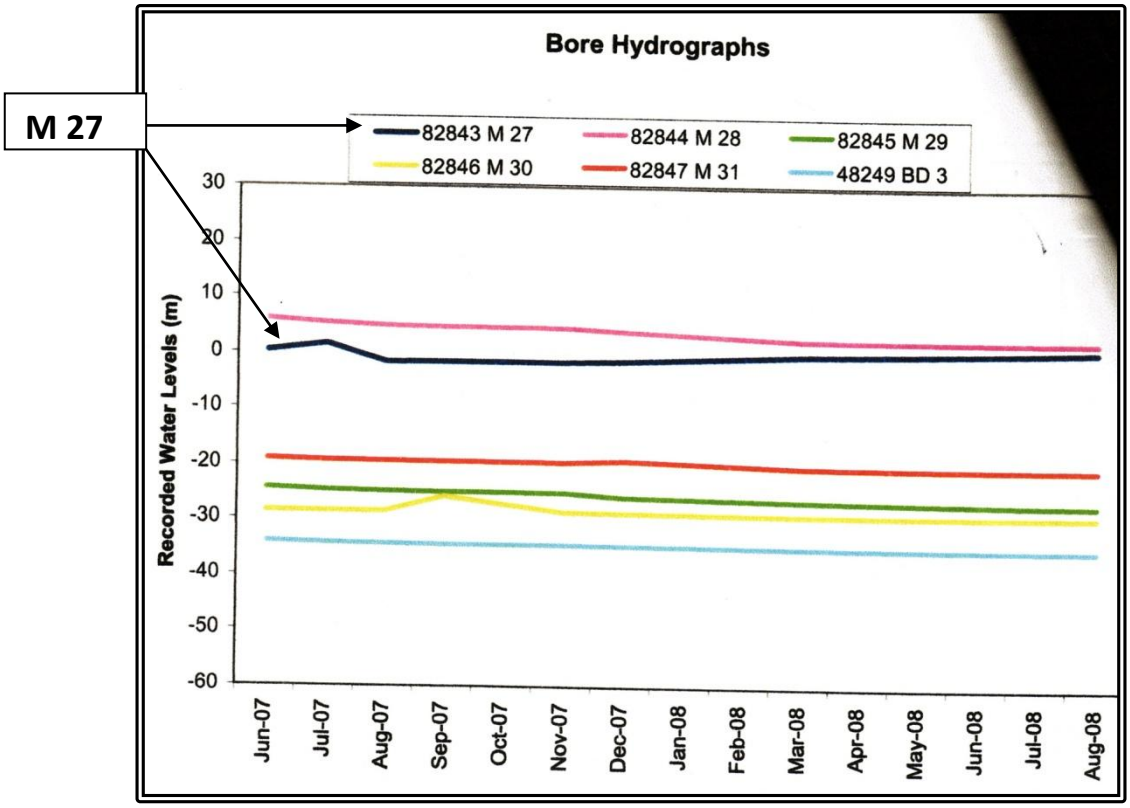
The following seven Barwon Water graphs for the reporting period 2004-2012 have been included so that the SRW hydrographs for observation Bores ID 82843 (M27) and M 29 can be compared.

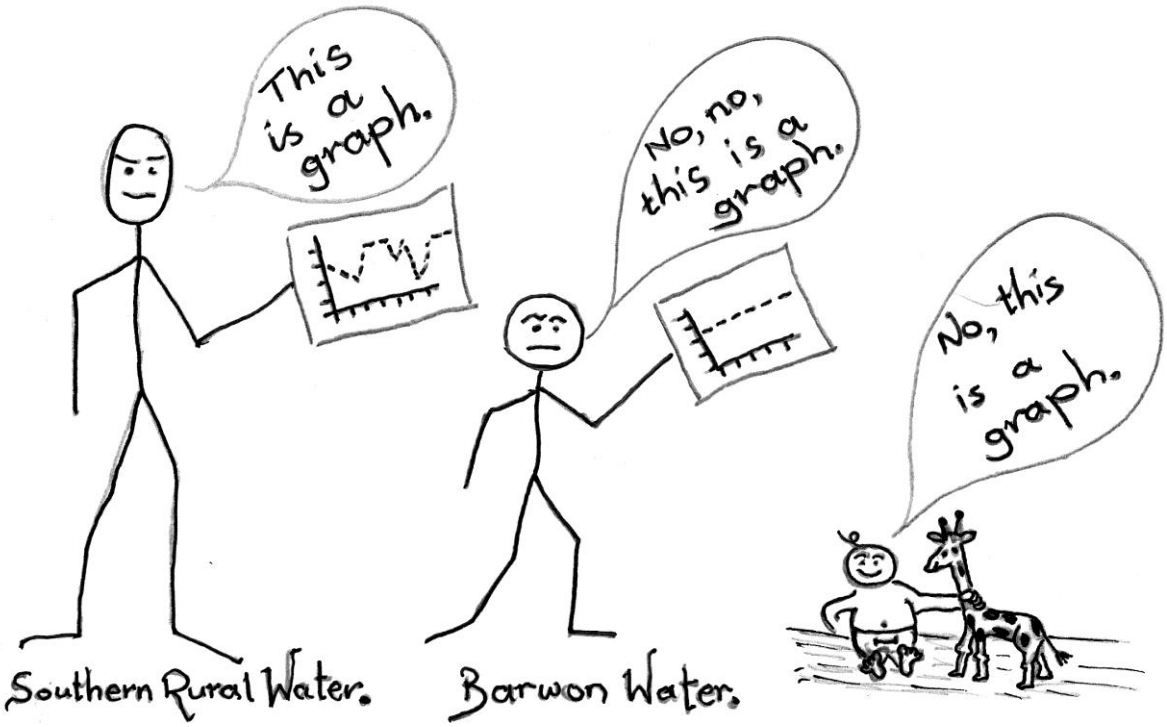




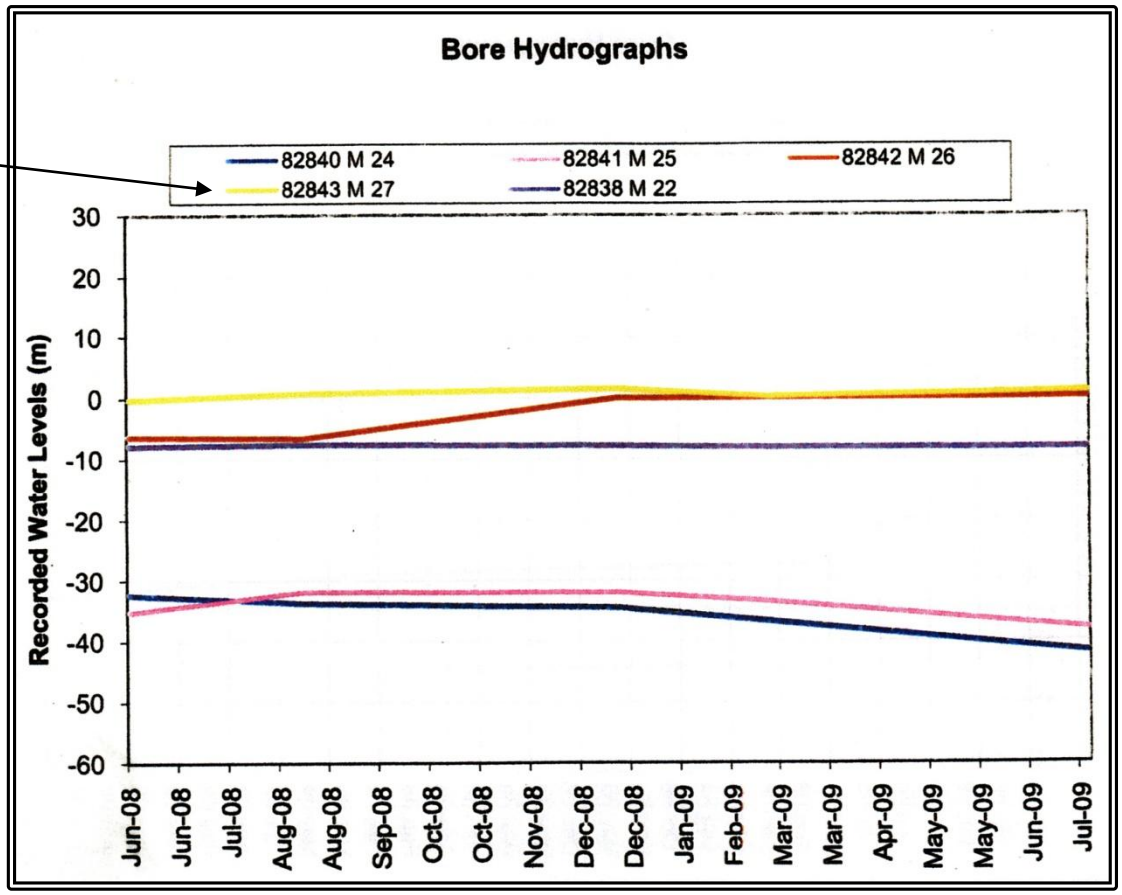

M 27
Bore Hydrographs
82843 M 27
82844 M 28
82845 M 29
82846 M 30
82847 M 31
48249 BD 3
Recorded Water Levels (m)
30
20
10
0
-10
-20
-30
-40
-50
-60
Jul-05
Aug-05
Sep-05
Oct-05
Nov-05
Dec-05
Jan-06
Feb-06
Mar-06
Apr-06
May-06
Jun-06


M 27
Bore Hydrographs
82843 M 27
82844 M 28
82845 M 29
82846 M 30
82847 M 31
48249 BD 3
Recorded Water Levels (m)
30
20
10
0
-10
-20
-30
-40
-50
-60
Jul-06
Aug-06
Sep-06
Oct-06
Nov-06
Dec-06
Jan-07
Feb-07
Mar-07
Apr-07
May-07
Jun-07


M 27
Bore Hydrographs
82843 M 27
82844 M 28
82845 M 29
82846 M 30
82847 M 31
48249 BD 3
Recorded Water Levels (m)
30
20
10
0
-10
-20
-30
-40
-50
-60
Jun-07
Jul-07
Aug-07
Sep-07
Oct-07
Nov-07
Dec-07
Jan-08
Feb-08
Mar-08
Apr-08
May-08
Jun-08
Jul-08
Aug-08


This is a graph.
No, no, this is a graph.
No, this is a graph.
Southern Rural Water.
Barwon Water.

M 27


Bore Hydrographs
82840 M 24
82841 M 25
82842 M 26
82843 M 27
82838 M 22
Recorded Water Levels (m)
30
20
10
0
-10
-20
-30
-40
-50
-60
Jun-08
Jun-08
Jul-08
Aug-08
Aug-08
Sep-08
Oct-08
Oct-08
Nov-08
Dec-08
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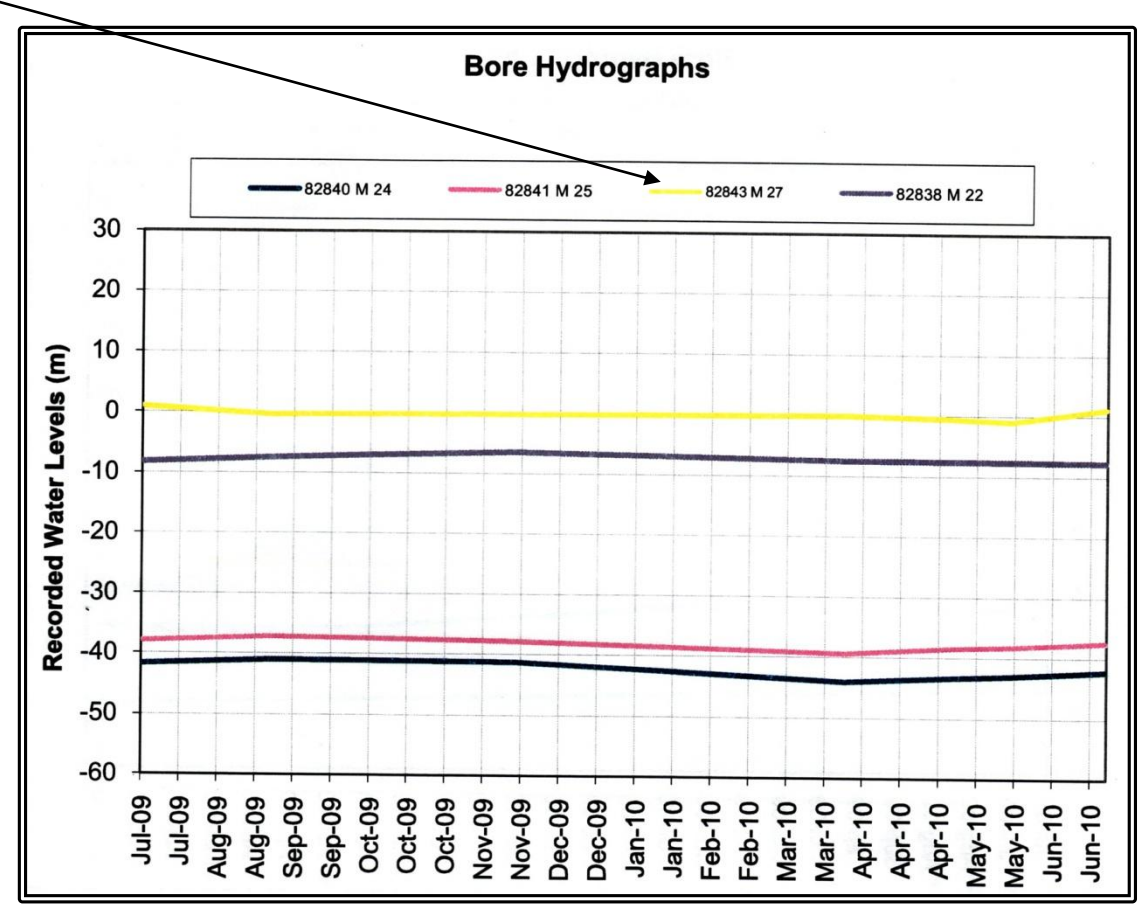
Mar-09
Mar-09
Apr-09
May-09
May-09
Jun-09
Jul-09


Bore Hydrographs
82840 M 24
82841 M 25
82843 M 27
82838 M 22
Recorded Water Levels (m)
30
20
10
0
-10
-20
-30
-40
-50
-60
Jul-09
Jul-09
Aug-09
Aug-09
Sep-09
Sep-09
Oct-09
Oct-09
Oct-09
Nov-09
Nov-09
Dec-09
Dec-09
Jan-10
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Mar-10
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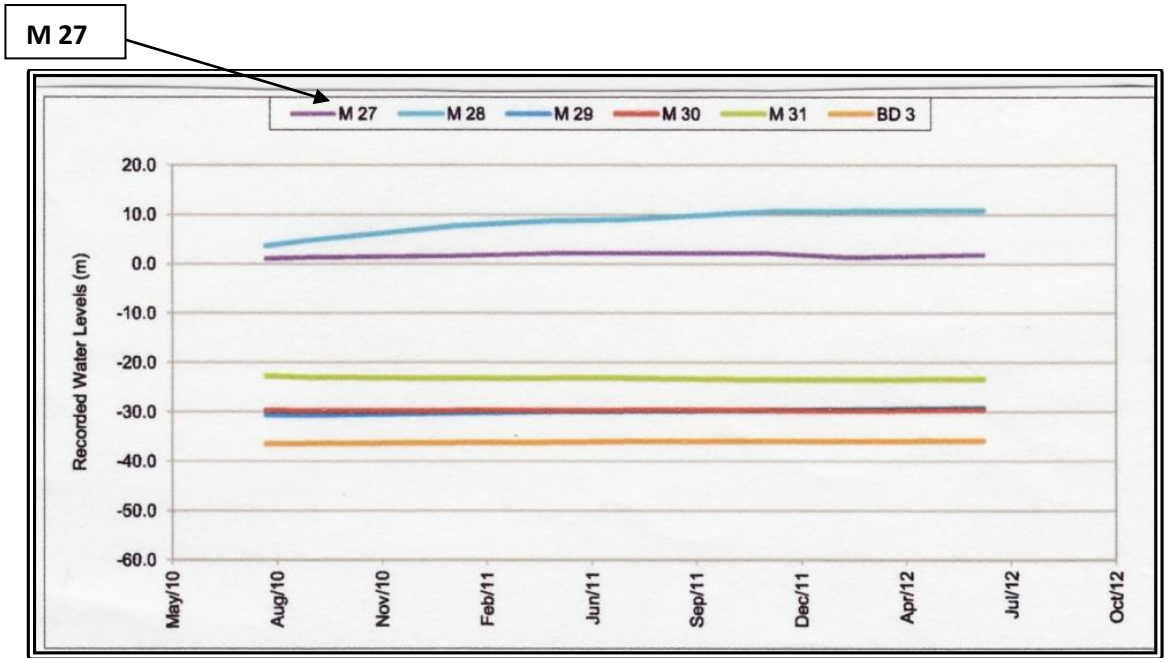
Apr-10
Apr-10
Apr-10
May-10
May-10
Jun-10
Jun-10

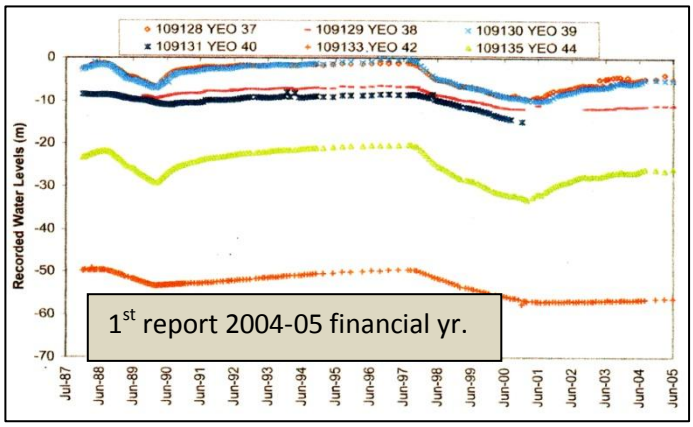


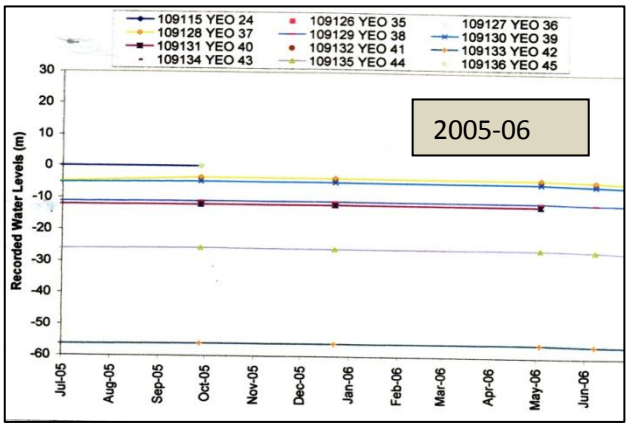
All of the observation bore hydrographs in the Barwon Water's 2004-2012 Reports display these relatively flat lines.

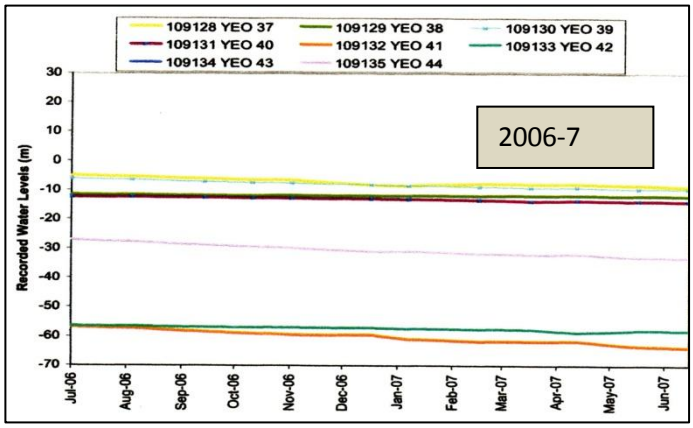
More Gobble-de-Gook

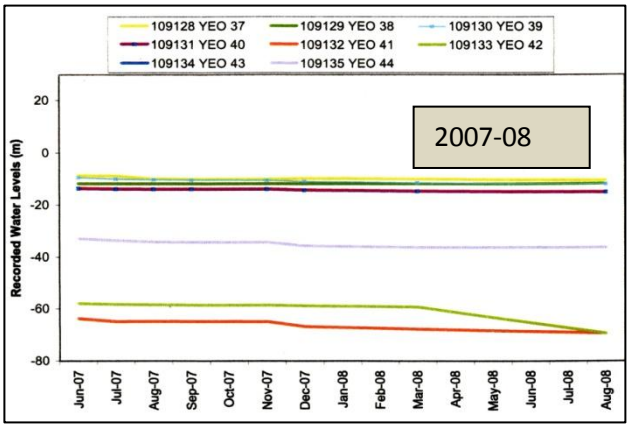
On the next page, page 45, four more examples of poorly presented data can be compared with the same data presented on the Southern Rural Water website...

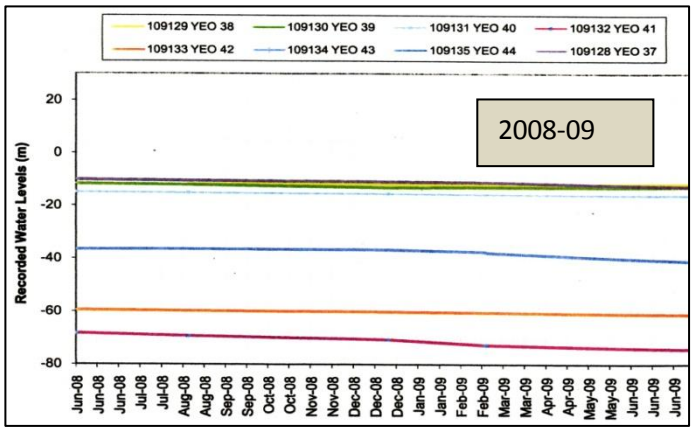
- Yeo 37, ID 109128 (see page 31 for Southern Rural Water hydrgograph),
- Yeo 39, ID 109130 (see page 28),
- Yeo 41, ID 109132 (see page 27) and
- Yeo 42, ID 109133 (see page 30).

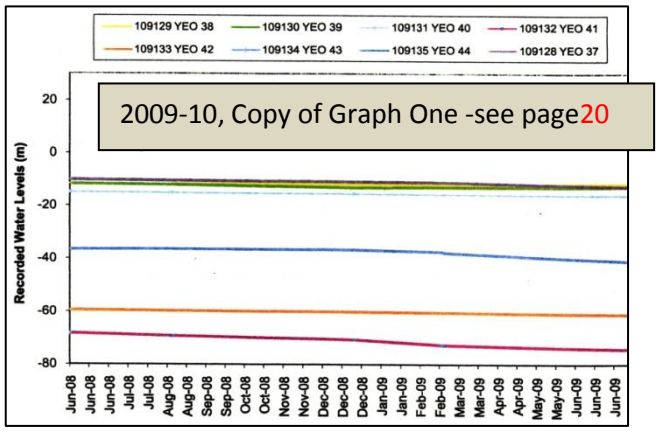


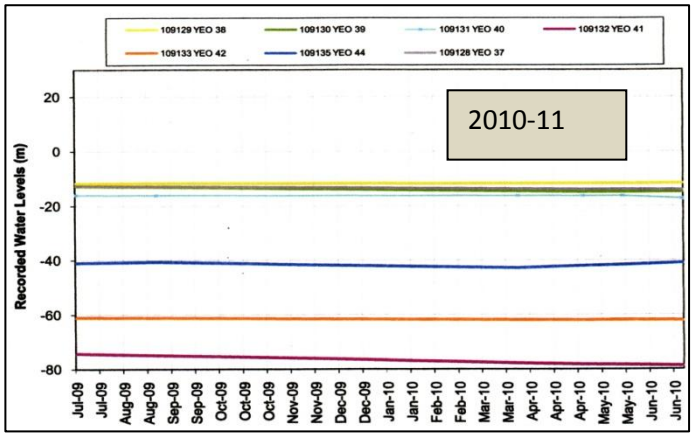


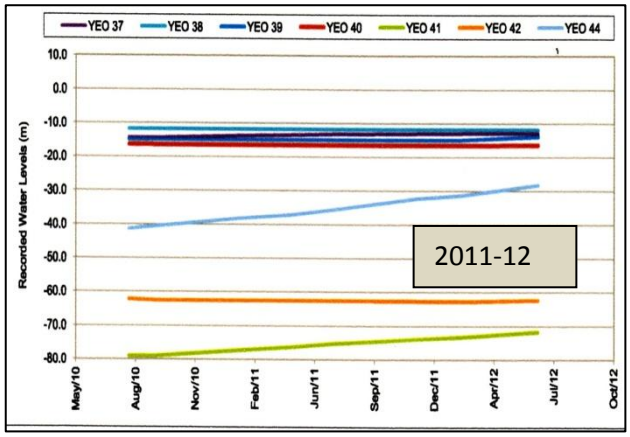












<u>SOURCE</u>: Barwon Water Gerangamete Groundwater reports to Southern Rural Water 2004-20012.

CHAPTER TEN
A Shifting Aquifer Divide.

The Hydro Technology report[7] includes the following statements:

> ***"The results from drilling undertaken in this program has provided sufficient data to accurately delineate the areas providing recharge to each sub-region."***
>
> ***"The southern and more prominent hydrogeological divide separates groundwater flow towards the Barwon Downs sub-basin from that moving into the Kawarren sub-basin."***

In another Hydro Technology report[6] this was stated:

> ***"The hydrogeological setting in the Kawarren region has been well established following recent investigations."*** (1994)

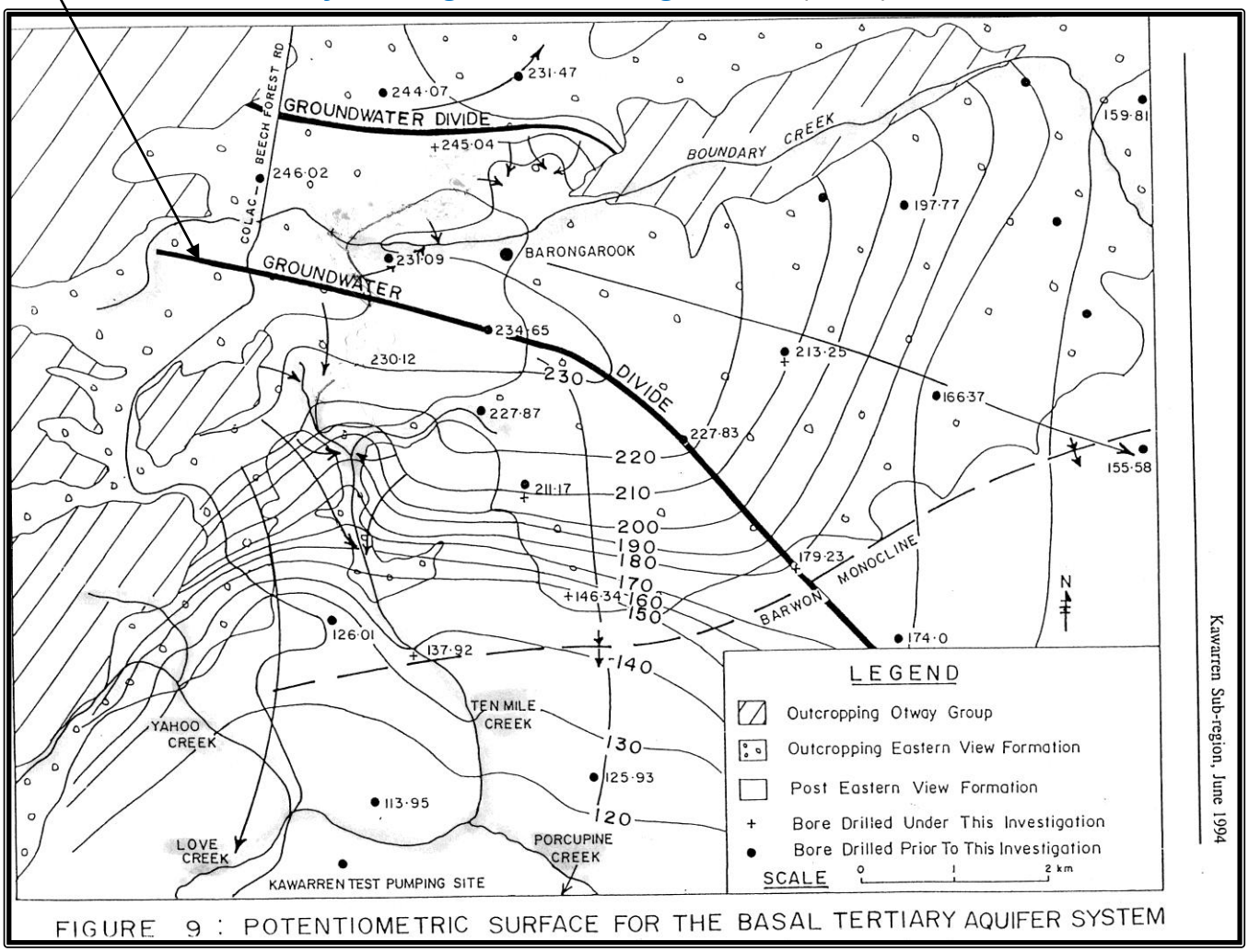


FIGURE 9 : POTENTIOMETRIC SURFACE FOR THE BASAL TERTIARY AQUIFER SYSTEM

<u>SOURCE</u>: Hydro Technology[7] (See page 51, Appendix One, for additional indication of this Aquifer Divide)

Years before Leonard[8] found a similar delineation of the groundwater flows in the EVF.

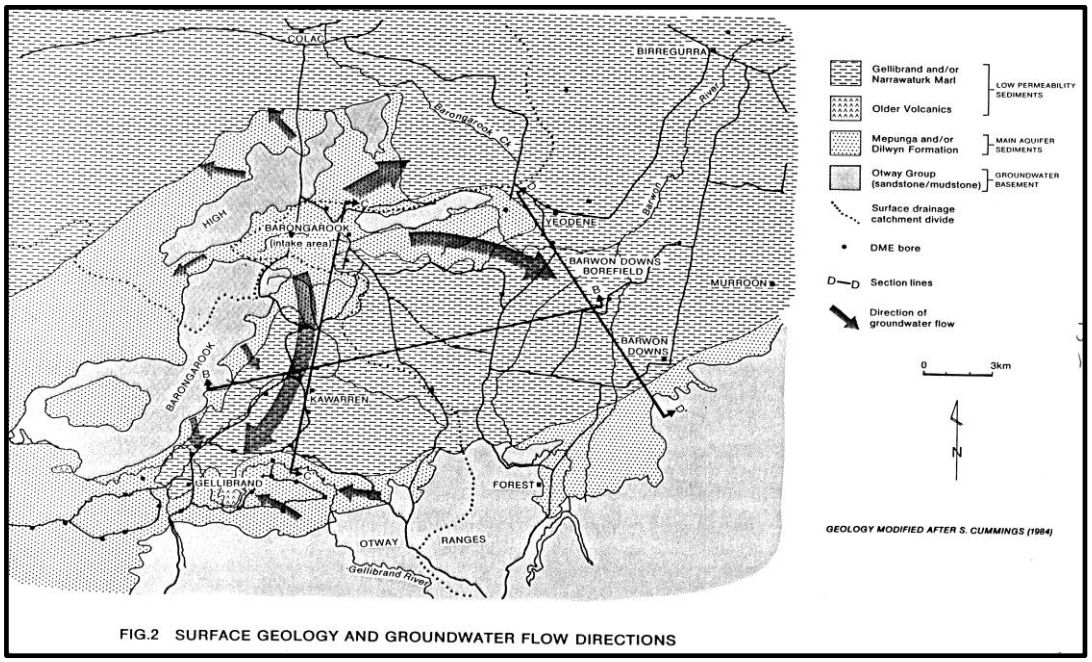


FIG.2 SURFACE GEOLOGY AND GROUNDWATER FLOW DIRECTIONS

SOURCE: Leonard[8]

This aquifer divide would account for the dissimilar hydrographs for the Kawarren and Barwon Downs areas as described in Chapter Nine.

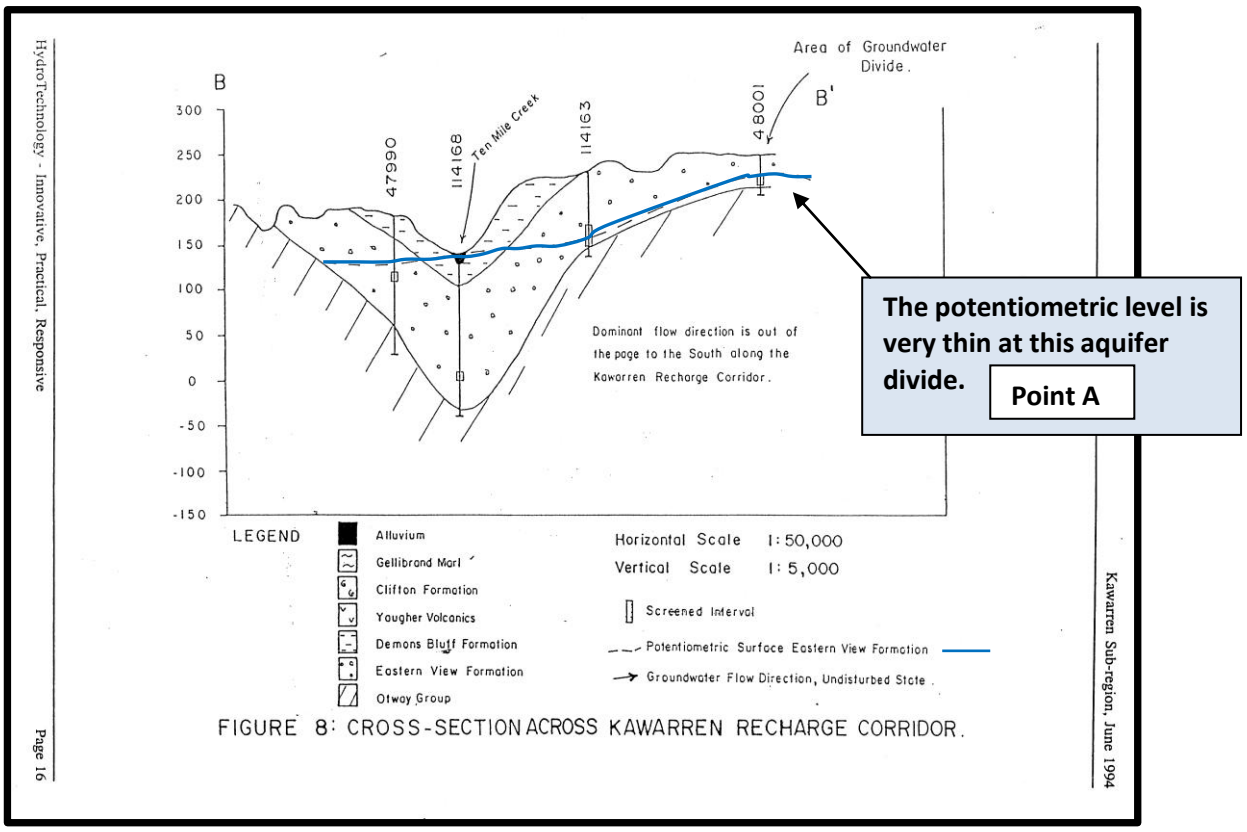
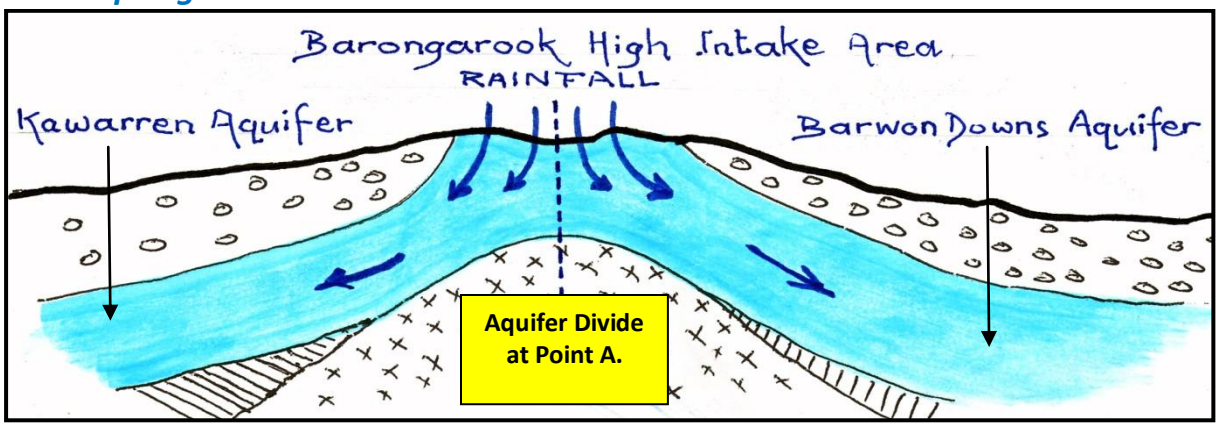


FIGURE 8: CROSS-SECTION ACROSS KAWARREN RECHARGE CORRIDOR.

SOURCE: Hydro Technology.

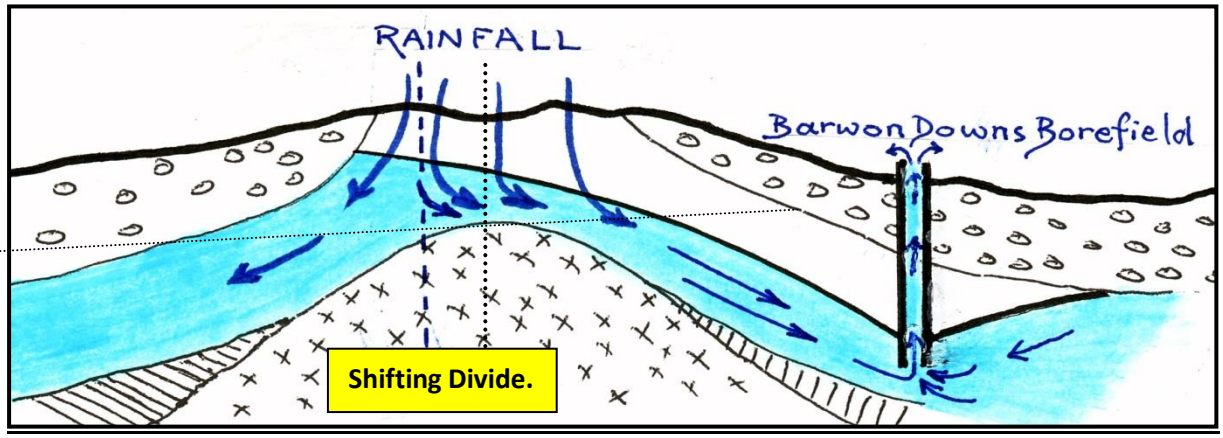
The Hydro technology report[7] also has this to say:

> ***"A prominent ground water divide controls the direction of flow across the Barongarook High and into the Barwon Downs Graben. Flow is generally to the east towards Yeodene and to the south towards Kawarren and Gellibrand."***
>
> ***"... the groundwater divide will shift in response to extraction and the degree of rejected recharge to the surface water systems, streams and springs will decrease."***



Conceptual Diagram.

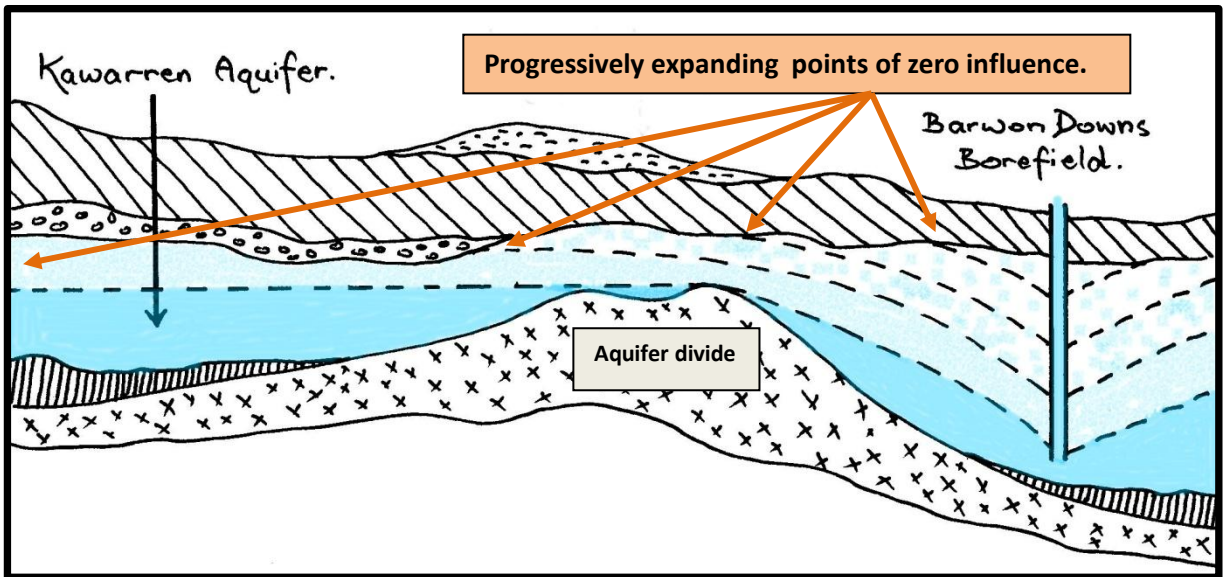
This conceptual diagram represents the position of the aquifer divide between the Barwon Downs Borefield and the Kawarren/Gellibrand area, pre groundwater extraction.



Conceptual Diagram.

This diagram illustrates how the extraction of groundwater at the Barwon Downs Borefield draws water towards the extraction bores that would normally flow in the Kawarren direction. This shifting of the aquifer divide closer to Kawarren in the Ten Mile Creek Catchment lessens the amount of recharge going into the Kawarren region of the EVF aquifer and could explain

why the Kawarren/Gellibrand observation bores hydrographs are continuing to decline.



Conceptual Diagram.

Not only does this shifting aquifer divide have an impact on the recharging of the Kawarren EVF but once groundwater extraction ceases the cone of depression, as it begins to fill, draws water from further and further away.

The hydrographs from the Kawarren/Gellibrand Region (see pages 25-37) show no response to three reasonably wet winters whereas during the same period the hydrographs in the Barwon Downs Borefield area of influence have shown considerable recovery. The aquifer storage and recharge that normally affects the Kawarren observation bores is being drawn away.

The fact that ***"The borefield was taken off-line in 2010 and has shown significant signs of recovery"*** (Extract from Barwon Water media release issued Thursday 21 June 2012) needs considerable clarification and explanation as to what is exactly taking place and why there are signs of a significant recovery, especially when, during the same period the neighbouring Gellibrand Groundwater Management Area hydrographs have continued to fall.

Besides having a profound effect on the water tables in the Gerangamete Groundwater Management Area there is every indication that the groundwater extraction at the Barwon Downs Borefield has also been impacting on the recharge and storage capacity of the Eastern View Formation in the Gellibrand Groundwater Management Area.

APPENDIX ONE

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 up to the point that 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

1. Setting Objectives and Prescribing Limits

~~Bulk Entitlements~~

Objective : To maintain a minimum flow in Boundary Creek for the environment and D&S users of 2 ml a day

Limits: A flow of 2 ML/d must be maintained at the stream gauge on Boundary Creek at Yeodene (233228) at all times

2 Mlg. Scenario 5

Historical data shows hadn't ever gone dry. Quality?

Reporting and Review of Monitoring

Reporting: Stream gauging data must be obtained from the monitoring contractor within 30 days of:
the end of each month between December and May
and the end of November for each year
The annual gauging data must be graphed at daily intervals and provided to the Authority in December of each year

Clarified. 100%

Quality

3. Compliance

Notification of exceedance: If daily flow in Boundary Creek at Yeodene falls below 1 ML/d for any day, the Authority must be notified within 60 days — Immediately.

Restriction Imposed: If flow falls below 1 ML/d at Yeodene the Authority will require Barwon Water to limit extraction until flow at Yeodene returns to at least 1 ML/d

~~What~~ How are B.W going to supply B.Creek.* Water supply to be in place before any more extraction 100%

~~extraction condition~~

~~ongoing~~ Due to aquafir depletion bondary may need artificial flow for extended time. time

15/5/02 — 8/6/02 — time take from release to Nellies

3-5 ml a day. time it reached 23-27 day to reach lost 1.5 ml (2yrs before water can be released)

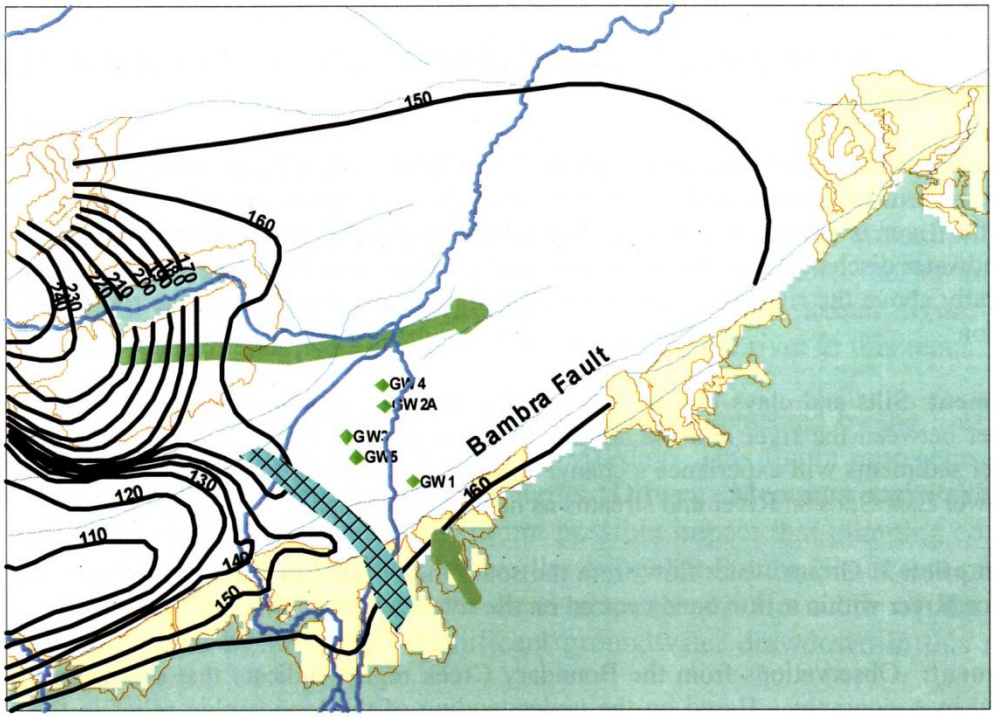
Source: Handout at Licence Review Panel early 2000s. Notation done at the meeting by community member of Geranagmete Flats Landcare Member.

APPENDIX TWO

SKM

Barwon Water
Recommendations for Groundwater Licence Conditions
14 May, 2003

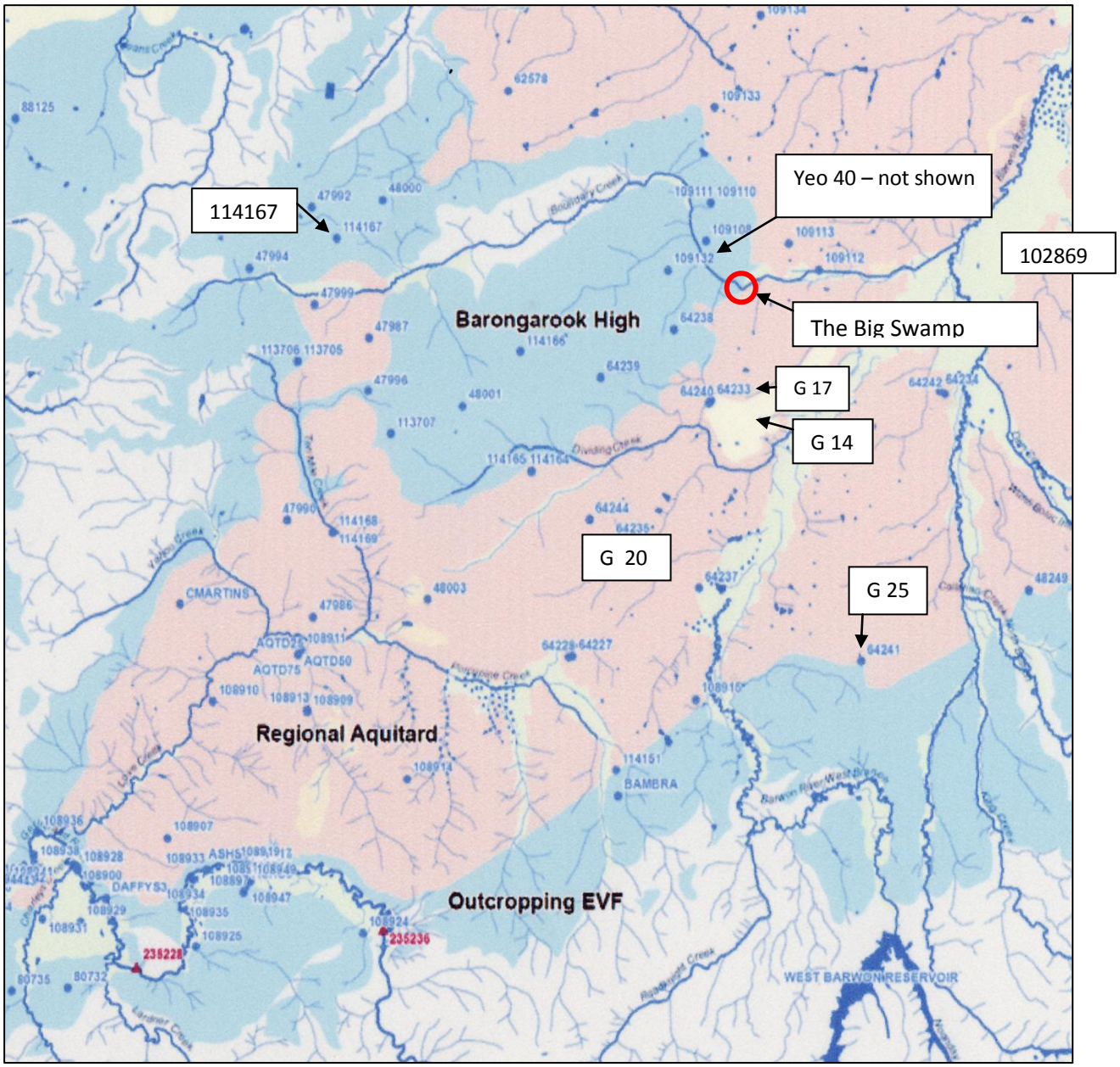
- **Figure 4-2 Flow Net for Dilwyn Formation to the South of the Modelled Area**



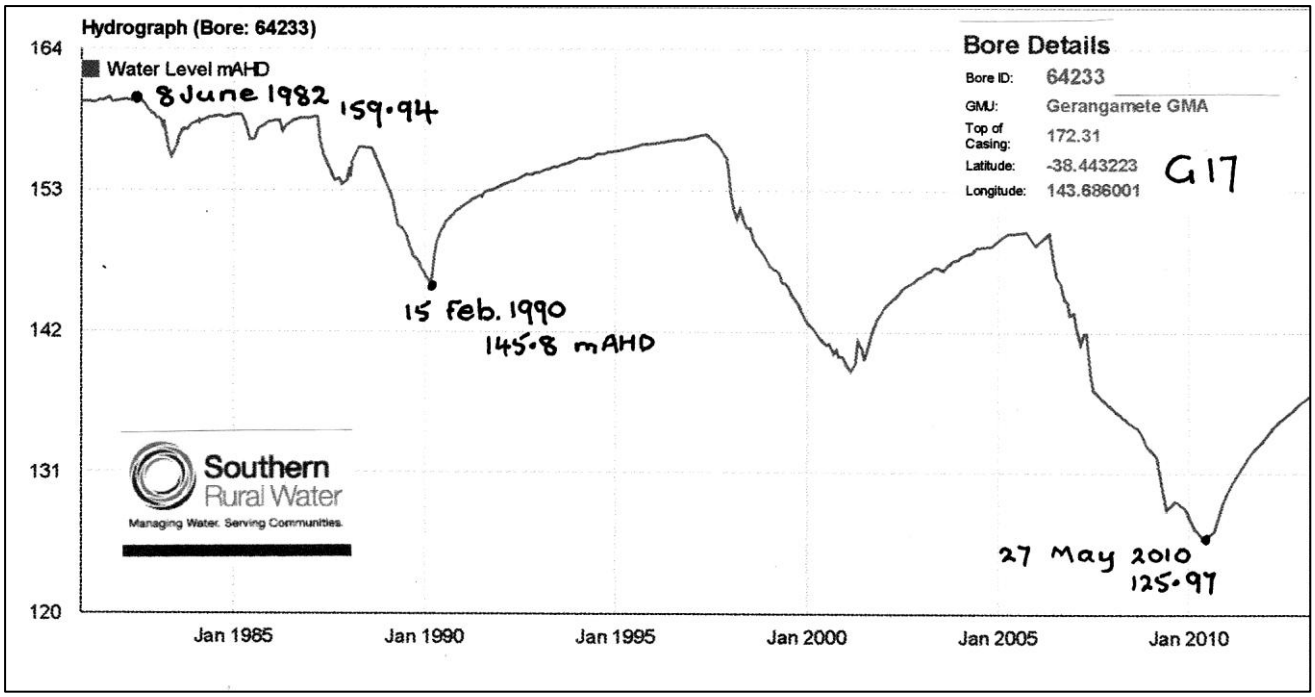
Production Bore
Groundwater Monitoring Bore
Groundwater Divide
Region of Basement Outcrop - Inactive Model Cells
Aquifer Outcrop in the South
Groundwater flow direction

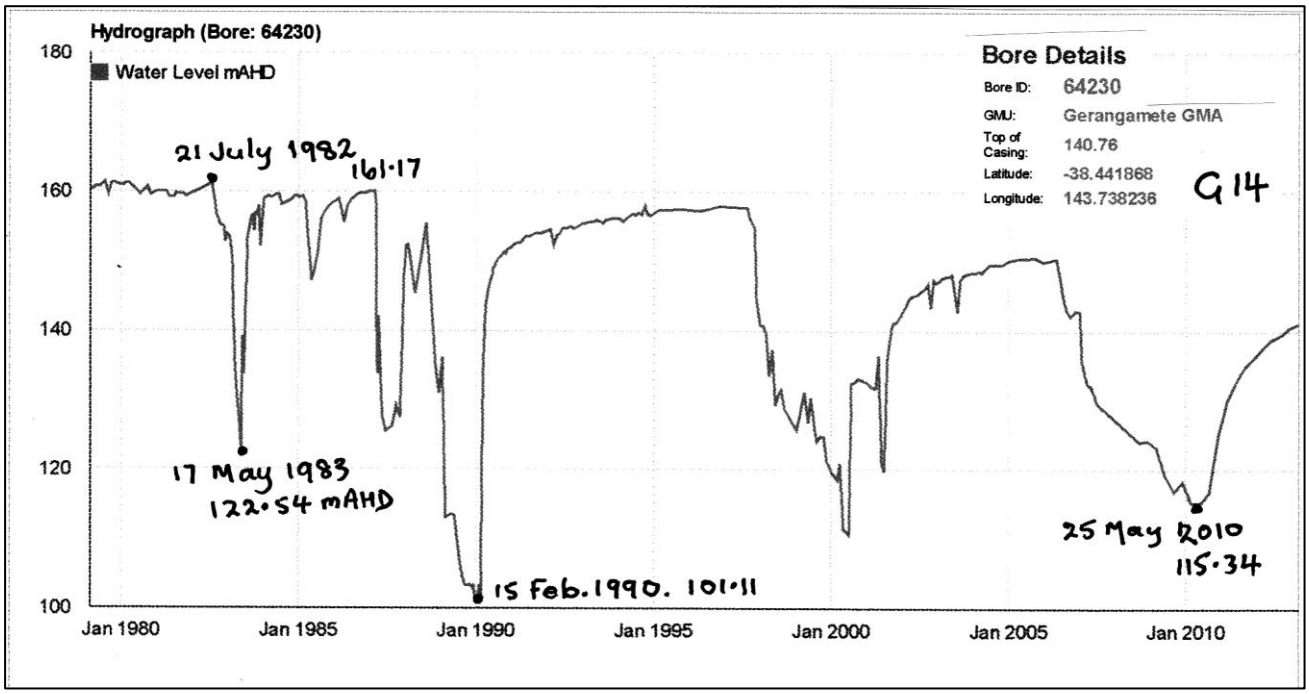
0 5000 10000

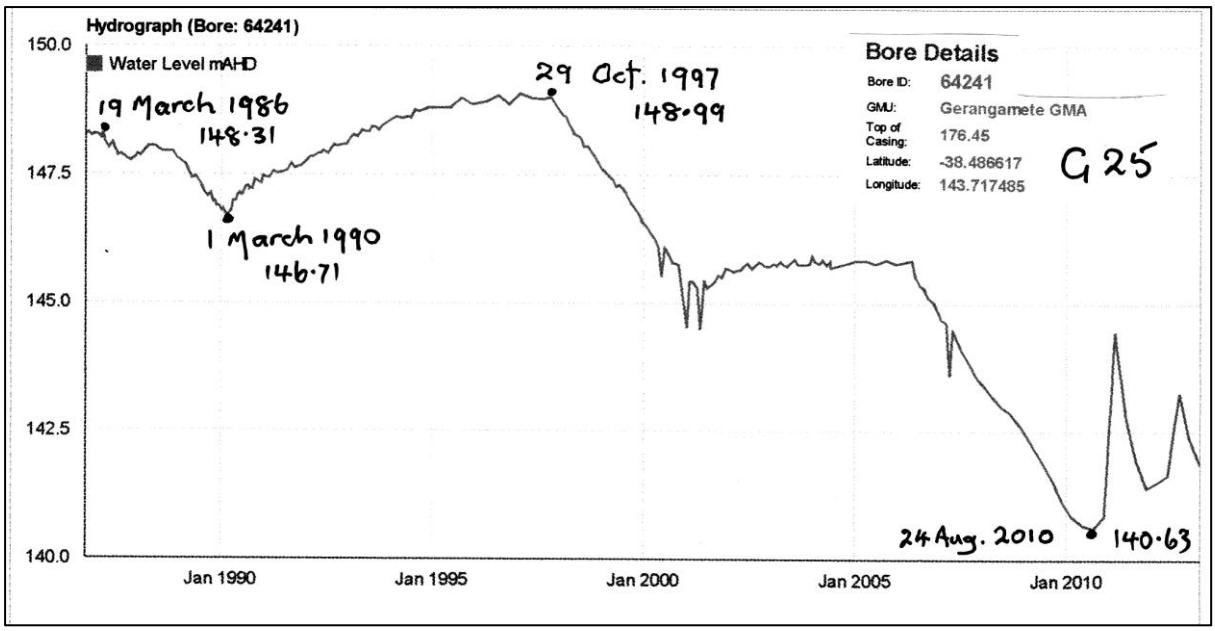
APPENDIX THREE

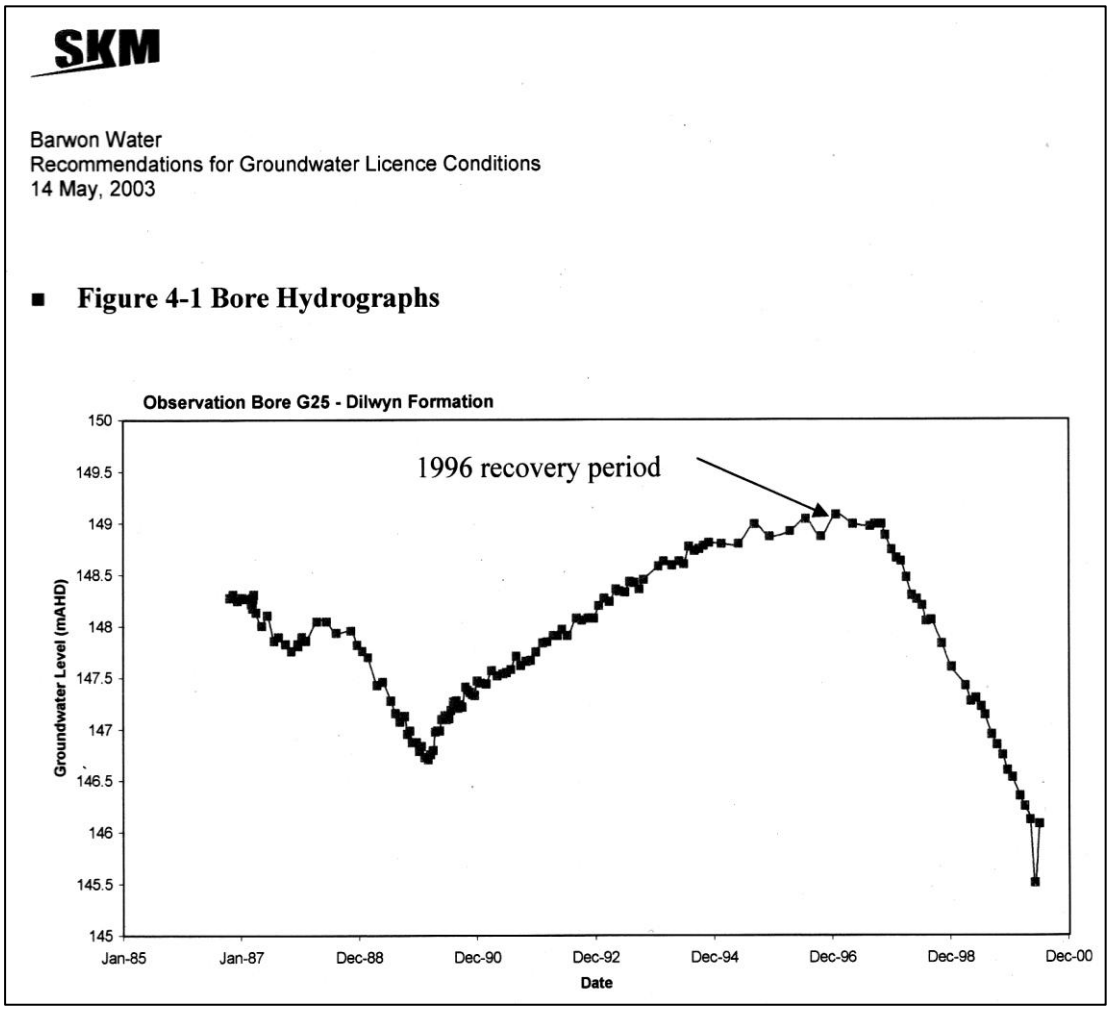


Observation Bore 102869 is found at the corner of Deepdene and Birregurra/Deans Marsh Roads – well off this map.

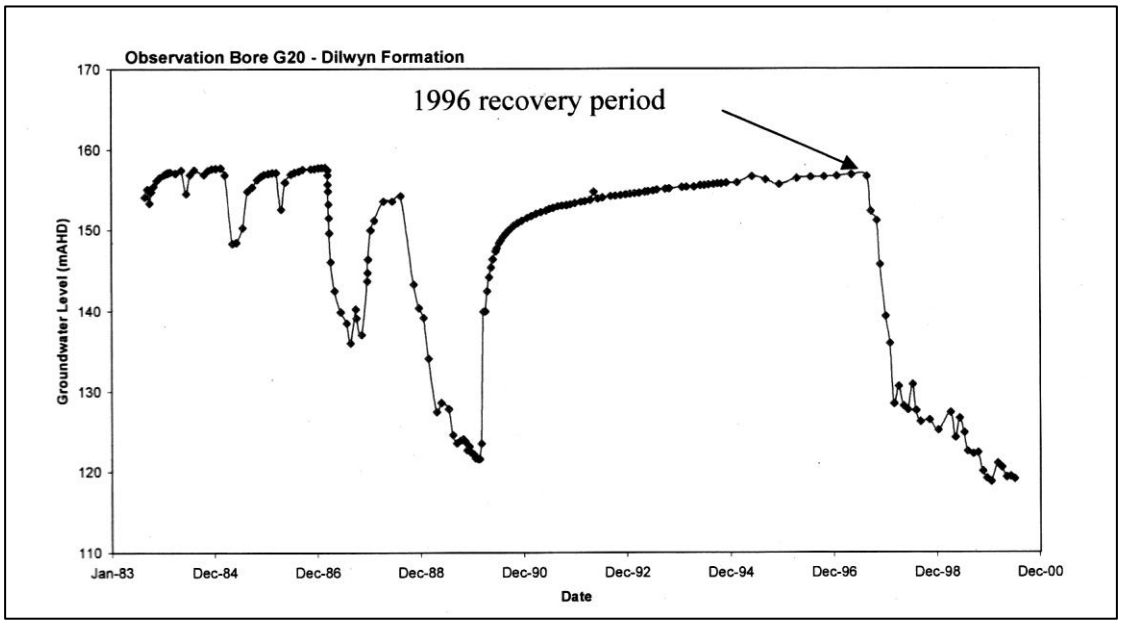

Hydrograph (Bore: 64233)
Water Level mAHD
Bore Details
Bore ID: 64233
GMU: Gerangamete GMA
Top of Casing: 172.31
Latitude: -38.443223
Longitude: 143.686001
G17
8 June 1982 159.94
15 Feb. 1990
145.8 mAHD
27 May 2010
125.97
Southern Rural Water
Managing Water. Serving Communities.
164
153
142
131
120
Jan 1985
Jan 1990
Jan 1995
Jan 2000
Jan 2005
Jan 2010


Hydrograph (Bore: 64230)
Water Level mAHD
Bore Details
Bore ID: 64230
GMU: Gerangamete GMA
Top of Casing: 140.76
Latitude: -38.441868
Longitude: 143.738236
G14
21 July 1982
161.17
17 May 1983
122.54 mAHD
15 Feb. 1990. 101.11
25 May 2010
115.34
180
160
140
120
100
Jan 1980
Jan 1985
Jan 1990
Jan 1995
Jan 2000
Jan 2005
Jan 2010



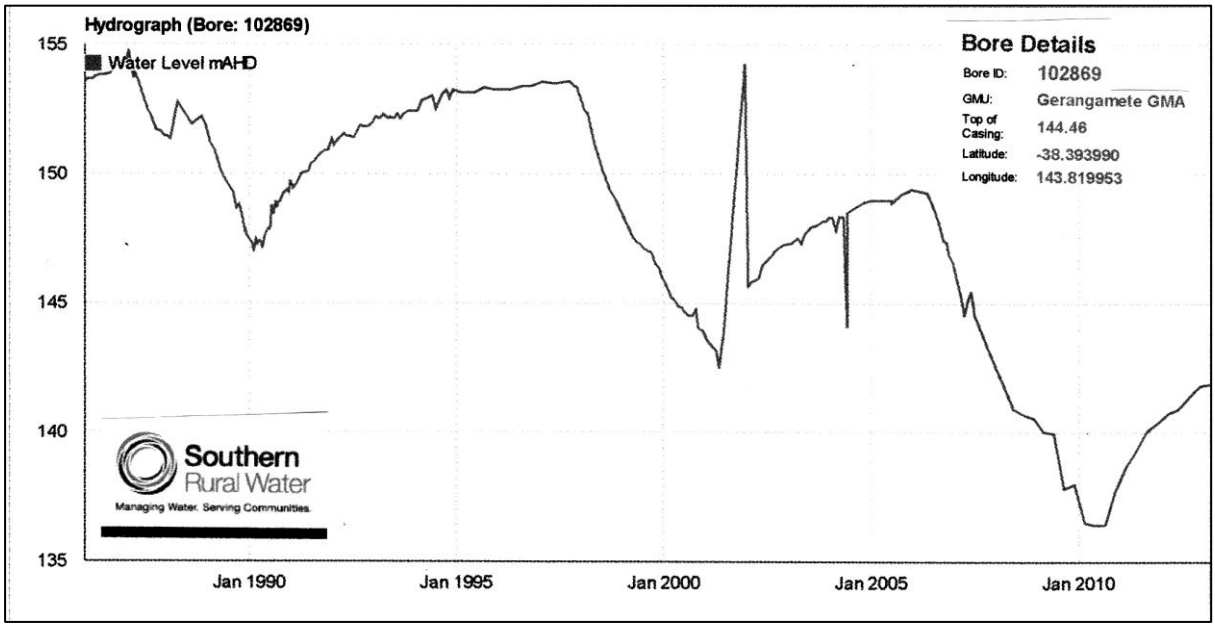


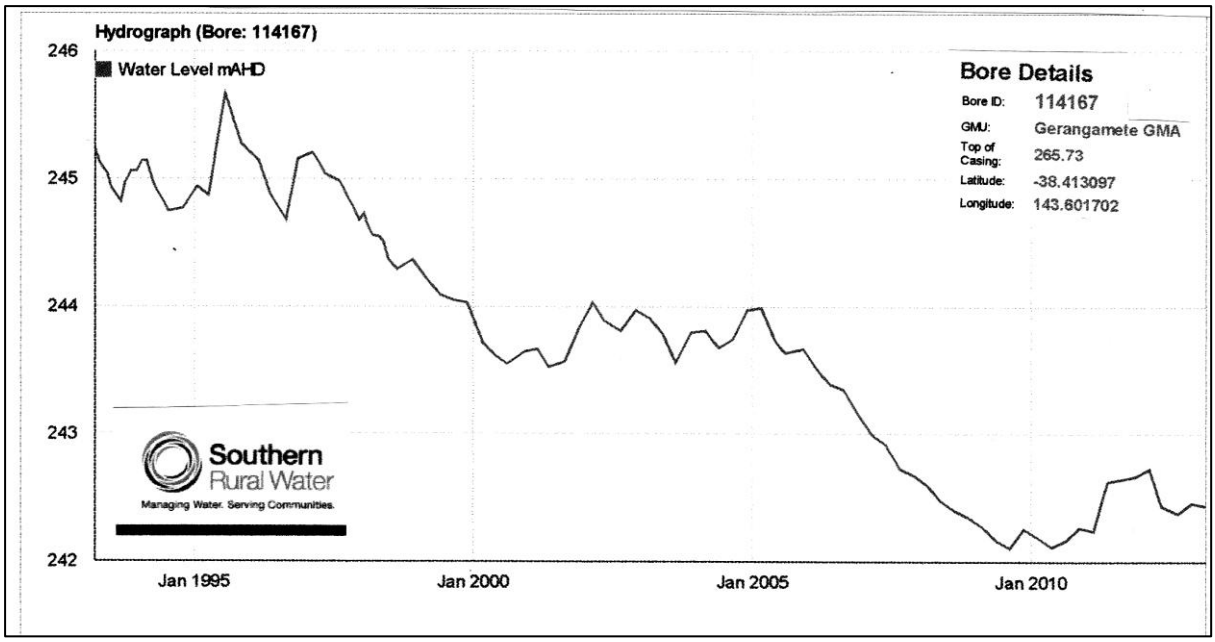
These two hydrographs are for the same Bore. The Southern Rural Water graph showing a little more detail.



This hydrograph for G 20 (ID 64236) has been copied from the 14 May 2003 SKM recommendations (as is the G 25 hydrograph on page 54).

Similar to other observation bores (109134, 64242, 109131, extraction bores) around the Barwon Downs Borefield, this bore's hydrograph (G20) cannot been sourced from the Southern Rural water website.




Hydrograph (Bore: 114167)
Water Level mAHD
246
245
244
243
242
Jan 1995
Jan 2000
Jan 2005
Jan 2010
Bore Details
Bore ID: 114167
GMU: Gerangamete GMA
Top of Casing: 265.73
Latitude: -38.413097
Longitude: 143.601702
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APPENDIX FOUR

In 1997 the top end of the Big Swamp had dried out to such a degree that when a wild fire swept through the area the top section of the swamp caught fire. The lower section of the swamp was still, at that stage, fully saturated and would not burn.

This would suggest that the 158.5 m AHD trigger point was set too high. The hydrograph on page 23 indicates the water table level to be above the 158.5 mark for this period. The Big Swamp should have been completely saturated. If this was so the Big Swamp would not have caught fire.

As the years passed with the water table dropping the dry area progressively increased downstream.

The following three pages have been taken from the 14 May 2003 SKM recommendations and discuss the setting of the 158.5 mAHD trigger level in the Observation Bore Yeo 40, I.D. 109131.

SKM

Barwon Water
Recommendations for Groundwater Licence Conditions
14 May, 2003

3. Maintenance of Flow in Boundary Creek

3.1 Background

Pumping from the Barwon Downs borefield reduces groundwater discharge to Boundary Creek. Barwon Water will be required to supply water to the creek at times when groundwater pumping is causing unacceptable impacts on the stream. It is proposed that a trigger level be defined in a monitor bore located close to the stream. The trigger level, together with a minimum "natural" flow at the gauging station, will define the times at which Barwon Water will be required to pump water into the creek.

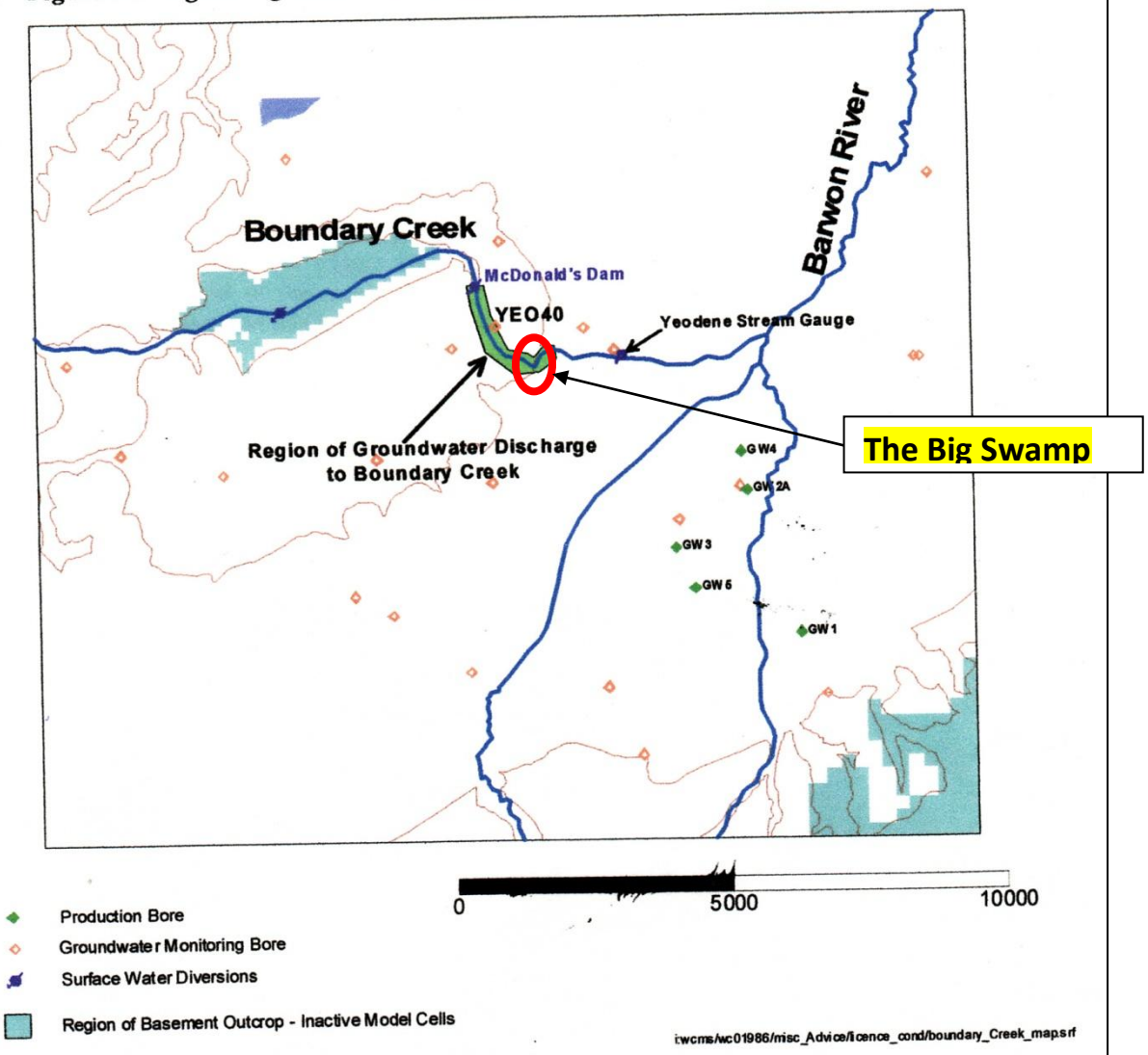
In setting a trigger level it is necessary to consider the natural variability of groundwater heads in the monitoring bore and to set a level that does not require Barwon Water to supplement stream flows when groundwater discharge is occurring within the normal range of seasonal variability.

Groundwater discharge to Boundary Creek is limited to that region where the creek bed crosses the aquifer outcrop and where creek stage level is below the prevailing groundwater head. The possible region of groundwater discharge to the creek is shown in Figure 3-1 below. It can be seen that discharge is limited to a relatively short stretch of creek bed downstream of McDonalds Dam. Land surface contours on the 1:25 000 topographic map (VICMAP, 1984) suggest that the creek bed levels vary from about 158 to 150mAHD over this stretch.

SKM

Barwon Water
Recommendations for Groundwater Licence Conditions
14 May, 2003

■ **Figure 3-1 Region of groundwater discharge to Boundary Creek**



3.2 Bore Selection

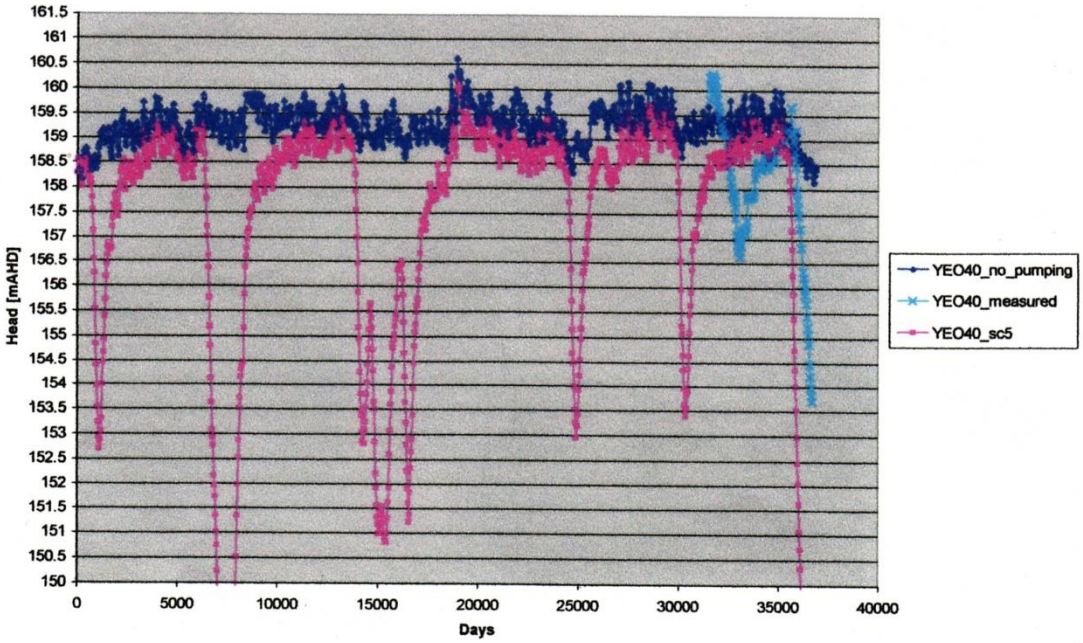
The bore used to monitor the trigger level for supplementing flow in Boundary Creek should be located near the creek and should be in the region where the aquifer is unconfined so that a direct connection between the creek and the bore can be assumed. Of the bores currently available there are two; namely YEO21 (GMS Bore #109112) and YEO40 (GMS Bore #109131) that are located close to Boundary Creek. Of these two bores, YEO21 is located close to the Yeodene stream gauge but is clearly located in a confined aquifer setting as it stands with an artesian head of 15 to 20m above ground level. YEO40 is located in the region of groundwater discharge to the creek and is believed to be in an area where the aquifer is unconfined. It is therefore recommended that water levels measured in YEO40 (GMS Bore #109131) be used to trigger the supplementary supply of water into Boundary Creek.

3.3 Setting the Trigger Level

In setting the trigger level for supplementary supply of water to Boundary Creek it is important to define a level that corresponds to the point where the creek converts from being a site of groundwater discharge to being a region of groundwater recharge. It is therefore appropriate to set the trigger level close to or slightly above the level of the creek bed at the uppermost point in the groundwater discharge region (158mAHD). It is proposed that a level 0.5 metre above the creek bed at the upstream limit of the discharge region be adopted. This level corresponds to 158.5mAHD. The creek bed at a point adjacent to YEO40 is at an elevation of approximately 156mAHD. The proposed trigger level therefore represents a groundwater head approximately 2.5m above the level of the nearby creek bed and groundwater discharge to the creek would be present when heads are at this level in YEO40.

To help illustrate whether the proposed trigger level is appropriate, Figure 3-2 shows heads measured and predicted in YEO40. The "no pumping" record and the Scenario 5 record presented in the figure are model predictions of heads over a 100 year period. The measured heads presented in Figure 3-2 represents the heads measured in the well since the mid-1980's and reflects the drawdown that occurred in response to borefield pumping. The measured heads during pumping and the predicted heads in Scenario 5 both indicate that as the borefield is pumped, heads in YEO40 are expected to fall below 158.5m. On the basis of these observations and predictions, it seems appropriate that 158.5mAHD be adopted as the trigger level in YEO40.

- **Figure 3-2 Measured and predicted heads in YEO40**



3.4 Recommended Trigger Level

Barwon Water will be required to provide supplementary flow to Boundary Creek when flow at the gauging station is less than 1 ML/day and the groundwater head measured in the Bore YEO40 (GMS Bore #109131), or replacement bore drilled at this location, falls below 158.5mAHD.

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