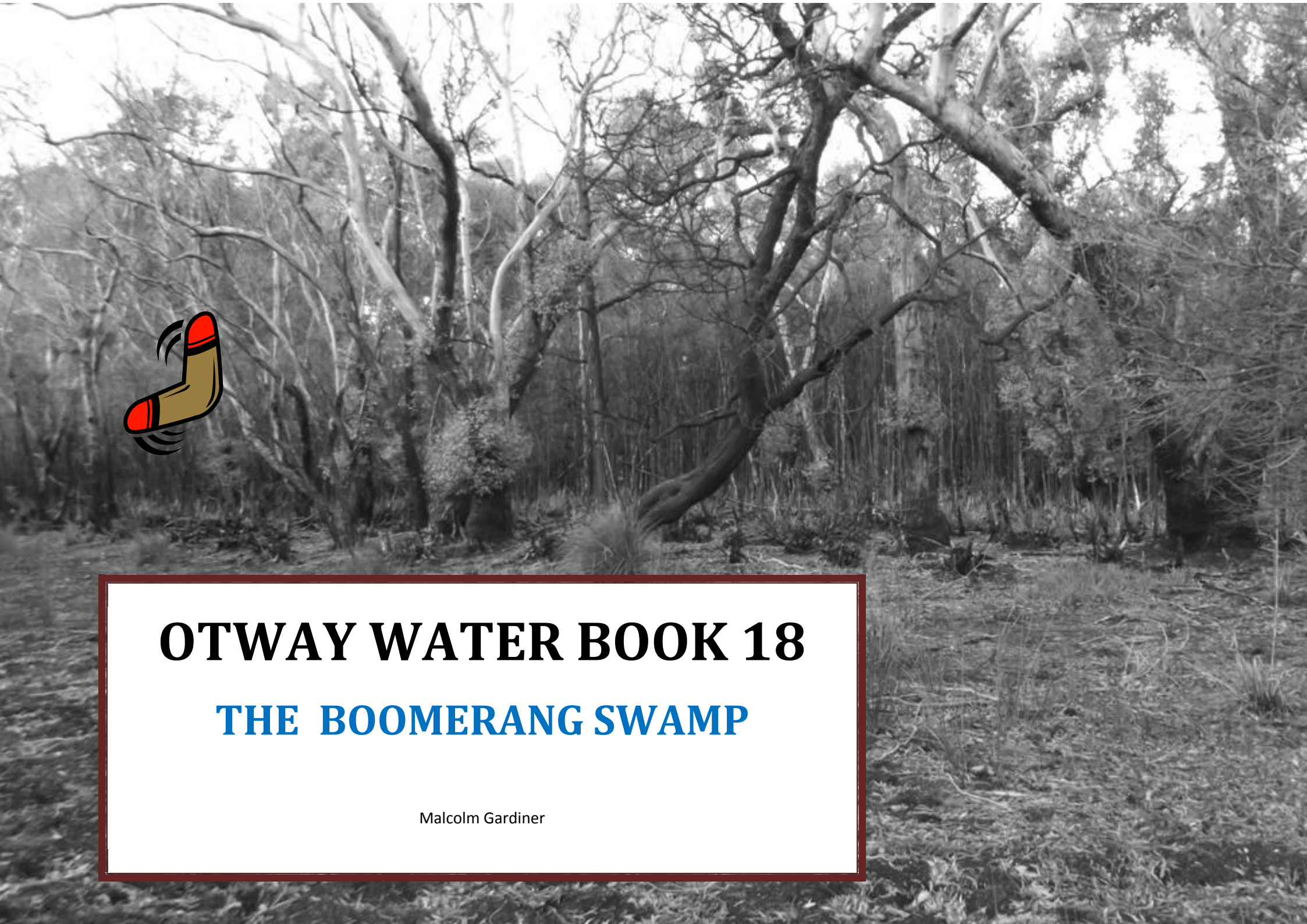

OTWAY WATER BOOK 18

THE BOOMERANG SWAMP

Malcolm Gardiner

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January 2013

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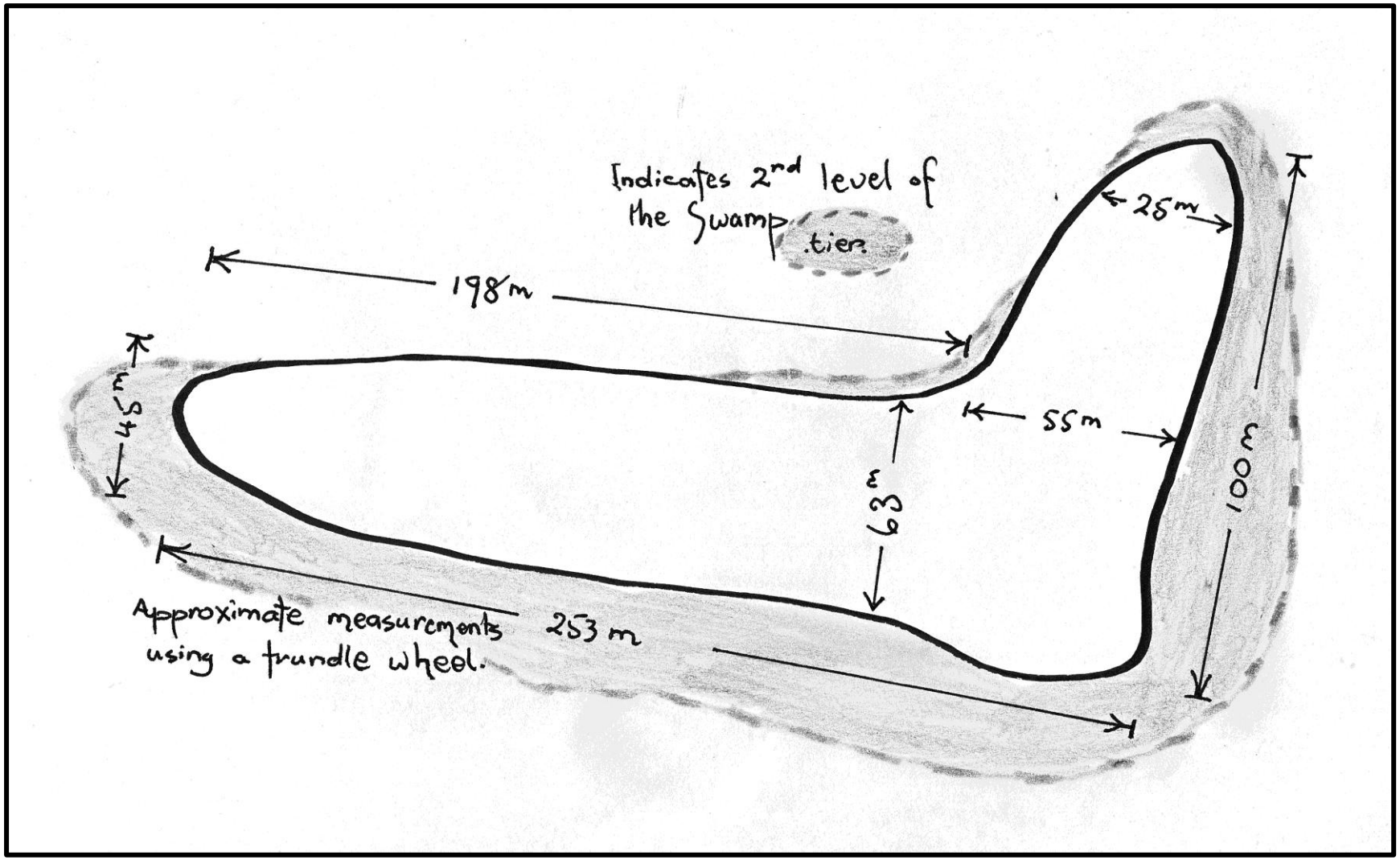
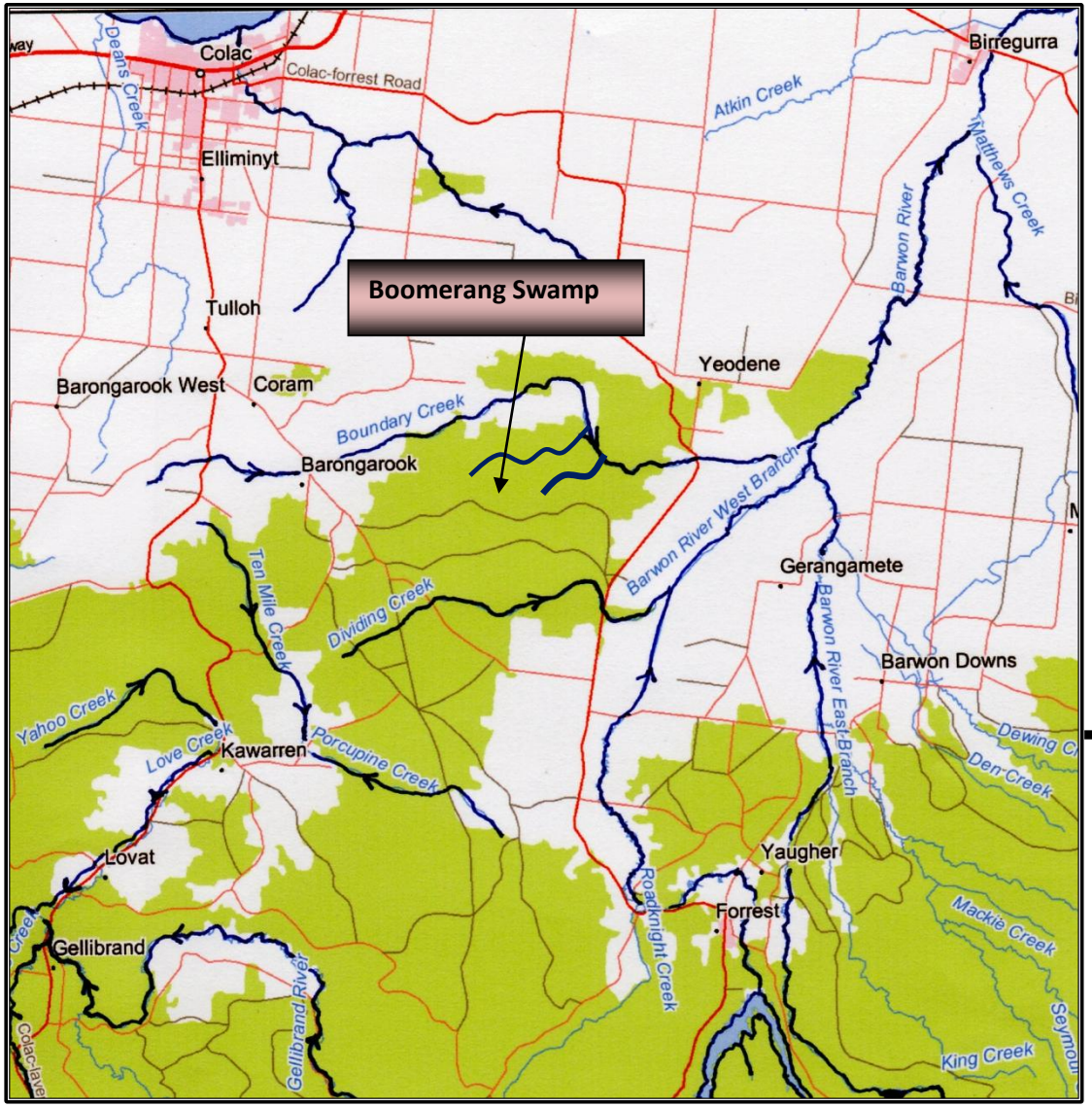
FOREWORD

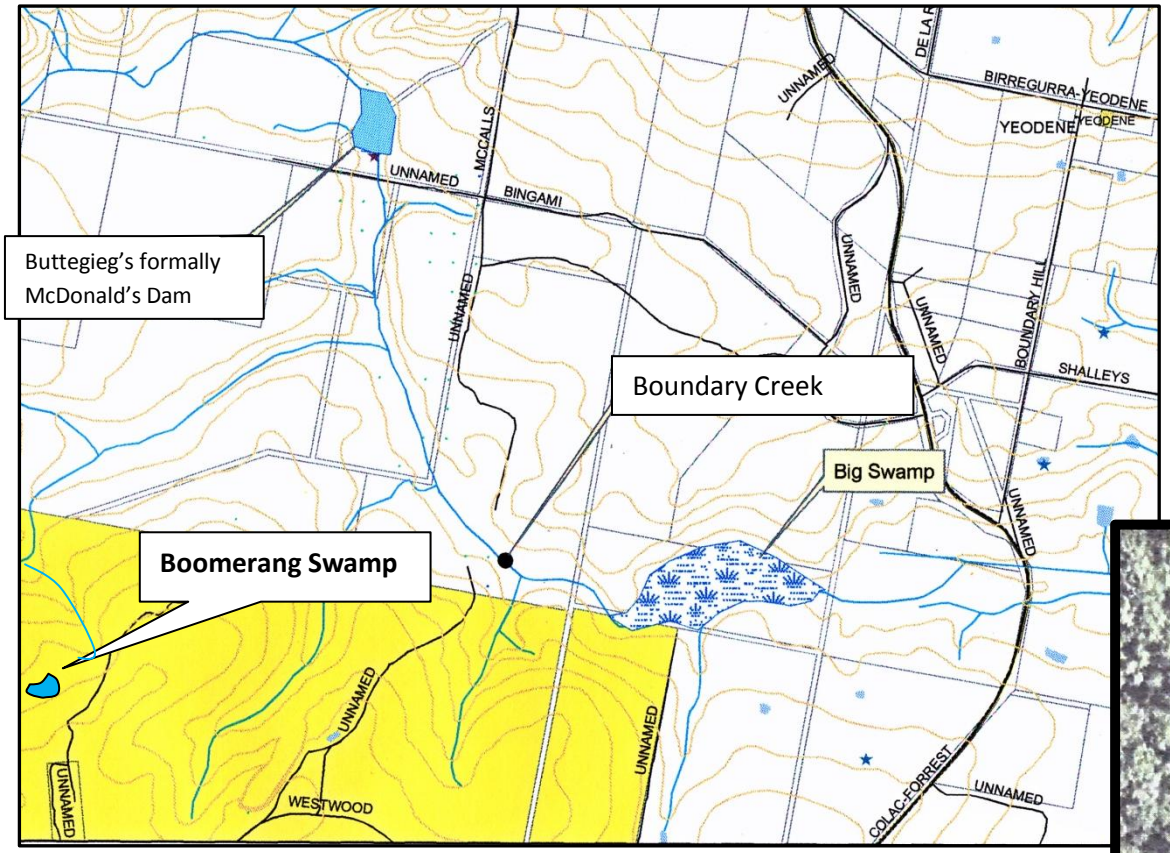
BOOMERANG SWAMP...trundle wheel measurements giving an indication of size only.(see page 13 for Carr & Muir measurements)



LOCATION MAPS



Boomerang Swamp is located in an area of the foothills of the Otway Ranges known as the Barongarook High, a recharge area for the deep aquifers Barwon Water extracts urban water from.

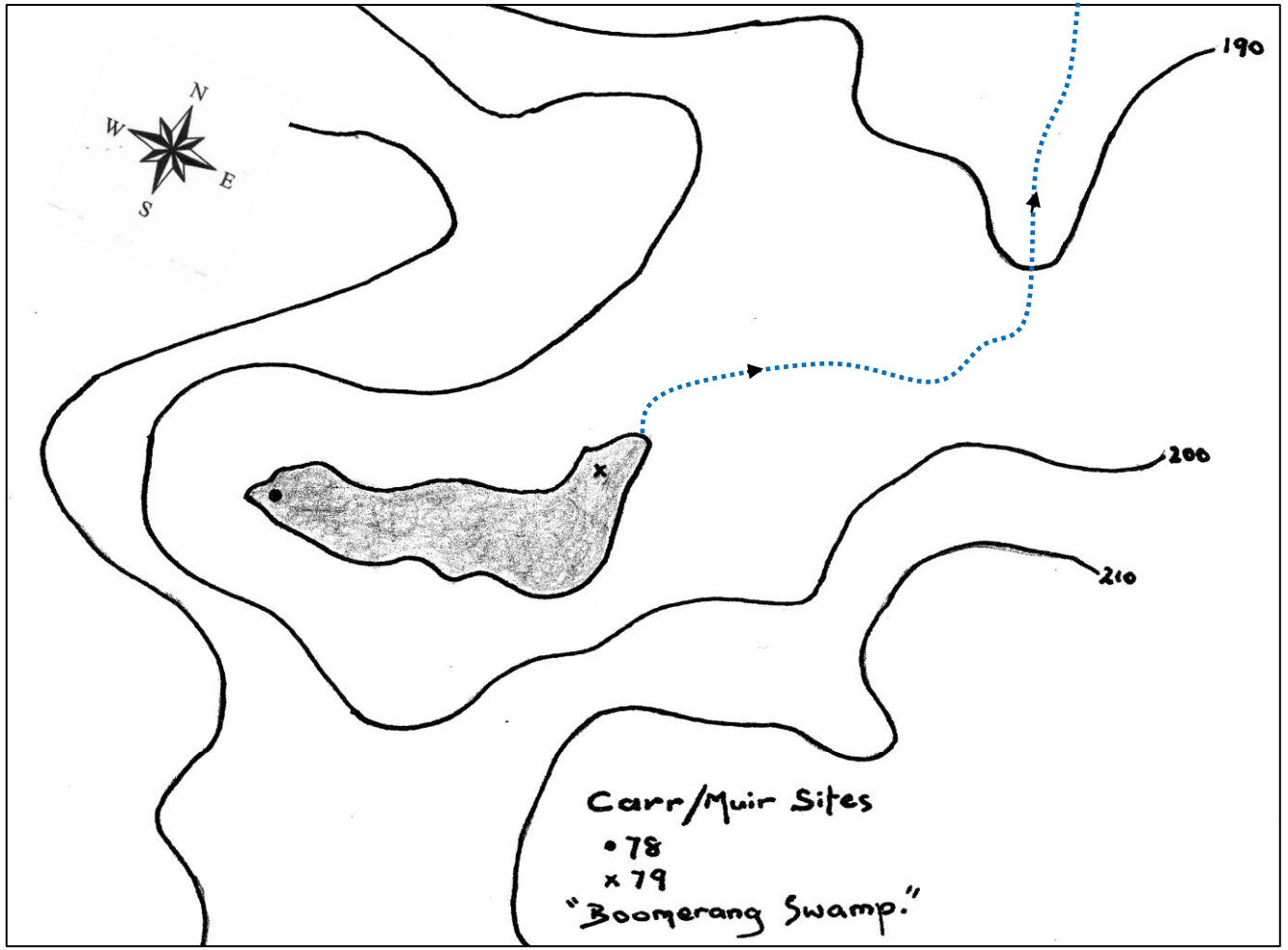


SOURCE: of the map Southern Rural Water

The flora survey sites established by Carr and Muir in the early 1990s. [6]

Site 78 is in the extreme west of Boomerang Swamp.

Site 79 is at the north east end of the swamp. The outlet or overflow from the Boomerang Swamp is in this corner of the swamp. This drainage line runs into and becomes a tributary of Boundary Creek upstream of the Big Swamp.



Introduction.

In a 1994 report the Boomerang Swamp was described as a rare high quality example of a greater than regional botanical significant swamp in an unmodified catchment. Unfortunately, since then this swamp has undergone a significant and dramatic decline to such a degree that this pristine swamp no longer supports very rare and significant vegetation.

When the swamp was resurveyed in the early 2000s, the 2002 report could not determine whether drought and or groundwater extraction was the cause of such a dramatic decline.

This book examines some of the decisions made going back as far as 1986 and questions whether they were made in the best interests of the survival of this swamp. The question is posed that decisions made were not based upon sound scientific evidence.

It is argued that if current scientific knowledge was taken into consideration the decisions made would have been markedly different and perhaps this swamp would have remained a site of State botanical significance and not border on becoming another Actual Inland Freshwater Acid Sulfate Soil site.

Boomerang Swamp in 2010.

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.[37] A pilot production bore was sunk in 1977.[37] The extraction rates for these periods cannot be located[16] by Barwon Water, the regional water authority involved.

1982

At the Barwon Downs Borefield during the drought of 1982-83 Barwon Water extracted around 8000 ML of groundwater.[37] 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. However, by doubling eight thousand it is doubtful that 16 000 ML of water would have been Geelong's total requirement. Considering that the extraction figures do vary depending on the source[23] there is every likelihood that the extraction figure was very much higher than 8 000 ML.

With the view of augmenting the amount of water that could be sustainably extracted from the Barwon Downs Borefield in the future, an extensive groundwater test pump was conducted between 1987 and 1991. Over this period the test pump extracted approximately 25 000 ML of water from the deep aquifers. This water was discharged into the Wurdee Boluc Inlet Channel and the Barwon River system.[18] At this stage environmental impacts from groundwater extraction were not considered.[18]

1986

However, in 1986 Farmar-Bowers tabled a report[14] specifically dealing with environmental considerations that should be taken into account before the 1987 test pump commenced. These environmental findings would form part of the evaluation when assessing the results of the 1987-1991 test pump. The objective of the Farmar-Bowers report for this phase one was to...

> "***Develop a program to clarify the environmental issues relevant to groundwater investigations in the Barwon Downs area and assist in directing the establishment of the appropriate monitoring program.***" This turned out to be a comprehensive 55 page report.

Farmar-Bowers included this statement in his summary...

> "***Extraction of groundwater from the Barwon Downs borefield could draw down groundwater levels in the Barongarook area. This may adversely affect riparian vegetation, vegetation associated with swamps and springs and some forest adjacent to these areas. Forest and woodland on higher terrain will not be affected. Perched water tables and variability in soils could mask the response of vegetation to lower groundwater levels. Lower groundwater levels may also reduce the flows in Boundary Creek.***"

Farmar-Bowers proposed that structural and floristic mapping defining the vegetation that had developed with an interaction with groundwater, and that permanent plots be established to monitor any vegetation changes.

In his letter (Rural Water Commission of Victoria ref: 85/3252, included in the front of his report) dated 27 November 1986 to the Department of Water Resources, 590 Orrong Road Armidale Victoria 3143, Farmar-Bowers wrote...

> "***The second part of the objective is to "assist in directing the establishment of the appropriate monitoring programme". I am keen to proceed with this and presume that this will be possible once the recommendations in my paper have been reviewed. When it is convenient I should like to discuss with you how this second part of the objective can be achieved.***"

In 1986 Farmar-Bowers recognised that if groundwater extraction was to proceed then...

"***... high quality(reliable) comparative environmental information is going to be required.***"

Significantly none of Farmar-Bowers's environmental studies were implemented.[18,19,25] The implementation of the second phase of the objectives never eventuated. An opportunity to collect high quality environmental information was overlooked.

1992

In 1992 ***after*** the 25 000 ML test pump had been conducted and in anticipation that an Environmental Effects Statement would be required before an approval for this augmentation could be obtained, Barwon Water drew up a contract brief titled, "Inventories and Assessments of the Flora and Fauna Values of the Barwon Downs Aquifer Outcrop Areas and the Streams Draining Them." The brief[26] mirrored much of Farmar-Bowers phase one recommendations and recognised that the Barwon Downs aquifer outcropped within the Boundary and Dividing Creek Catchments and were receiving discharge from the deep water aquifer. The Boomerang Swamp lies at the headwaters of a tributary of Boundary Creek in the Barongarook High aquifer outcropping area (see page 24 **in blue**).

The objective of the Barwon Water flora section of this brief was to gain an understanding of plant communities in the study area and identify particular species, communities and areas that are significant. It was identified that lowering water tables would have a consequent reduction in discharge from the deep water aquifers to certain areas at the surface. The survey work was to focus on areas and species that were most sensitive to changes in water tables. These areas needed to be identified as areas requiring further monitoring and evaluation.

1994

Carr and Muir of the firm Ecology Australia Pty Ltd, completed the flora section of this contract brief and presented their findings[6] to Barwon Water in June 1994. They sampled 82 quadrant sites.

"The vegetation was documented to detail its significance and identify vegetation types that may be hydrologically "sensitive", that is, potentially affected by water extraction by Barwon Water from the Barwon Downs groundwater wellfield."[6]

Plate 7. The perched swamp north of Westwood Road, site of Sub-community 6.3: Fine Twig-sedge Sedgeland (Quadrats 78 and 79). Fine Twig-sedge (foreground) is the dominant species, with taller clumps of Jointed Twig-sedge and Tall Rush visible in the middle distance. Also pictured is fringing Swamp Gum Forest (Community 4.0) with a Scented Paperbark understorey. This wetland and its catchment is a site of State botanical significance (Sb2).

SOURCE: Carr & Muir 1994.

Plate 9. Aerial view of the State significant swamp dominated by Fine Twig-sedge (*Baumea arthrophylla*) featured in Plate 7.

Having visited this swamp on numerous occasions this image always threw up a niggling concern. See Appendix One, page 107 for a possible reason and solution to this dilemma.

12

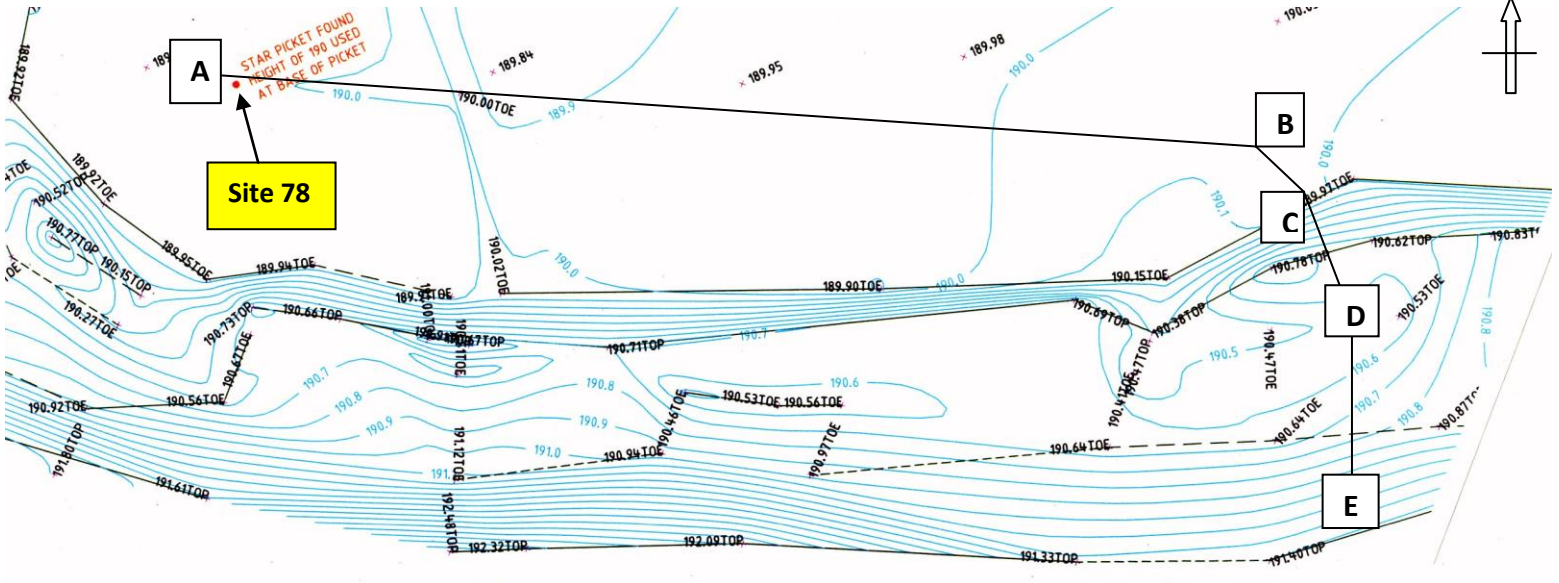
SOURCE: Carr & Muir 1994.

Ten sites were identified as having greater than regional botanical significance. Two sites 78 and 79, were identified in Boomerang Swamp. Site 78 contained eighteen species and Site 79 five species. These sites were located at opposite ends of the same c. 3 ha swamp. The Fine Twig-sedge Sedgeland found in this swamp was noted as of State biological significance. This wetland was in extremely good condition and was significant for the unusual nature of the vegetation as well as its intactness. The vegetation alliance covering the wetland was undocumented elsewhere in the region.[6]

The swamp was a "... ***rare example of a swamp in an unmodified catchment and so the site of significance includes the catchment***."[6]

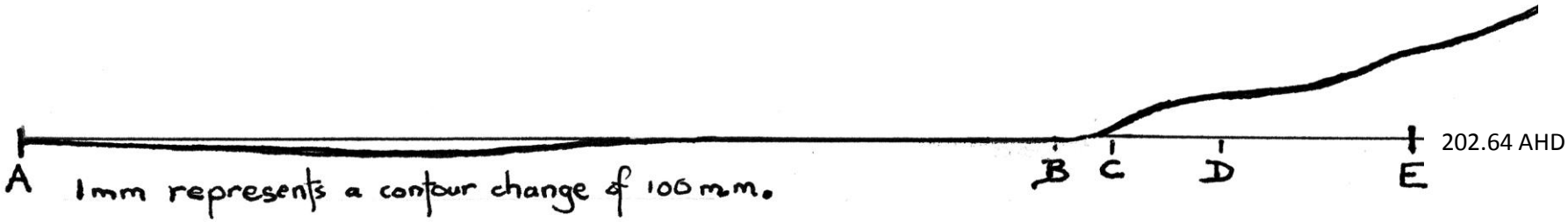
Carr and Muir[6] described this swamp as "... ***little free water over most of surface but soil permanently wet and boggy, northern end has the deepest water, c. 5-10 cm; water table presumed to be at or near surface – relationship between water table and surface topography needs to be clarified***..." The northern end of the Boomerang Swamp included Site 79.
The swamp was noted at an altitude of 195 m and c. 70 – 100 m wide and c. 300 m long, situated at the head of a relatively broad, gently sloping valley. The soils in the swamp being dark brown to black rich silt (peaty silt) and there was a dense amphibious and emergent aquatic herbfield to 2.5 m with fringing Eucalyptus ovate (Swamp Gum) forest.
Floristically Carr and Muir[6] described "***The swamp is encircled by Swamp Gum Forest with Blackwood (Acacic melanoxylon), Scented Paperbark (Melaleuca squarrosa), Red-fruit Saw-sedge (Gahnia sieberiana) and Variable Saw-sedge (Lepidoosperma laterale var. Majus) understorey. Interestingly the swamp is vegetated almost exclusively with suite of graminoids and Dark Swamp Wallaby-grass (Amphibromus recurvatis). FineTwig-sedge (Baumea arthrophylla) is the most common plant, with large clumps of the tall Jointed Twig-sedge (Baumea articulata) and Tall Rush (Juncus procerus). The ground layer is characterised by swards of Dark Swamp Wallaby-grass and frequent clumps of emergent aquatic Water-ribbons (triglochin alcockiae).***"

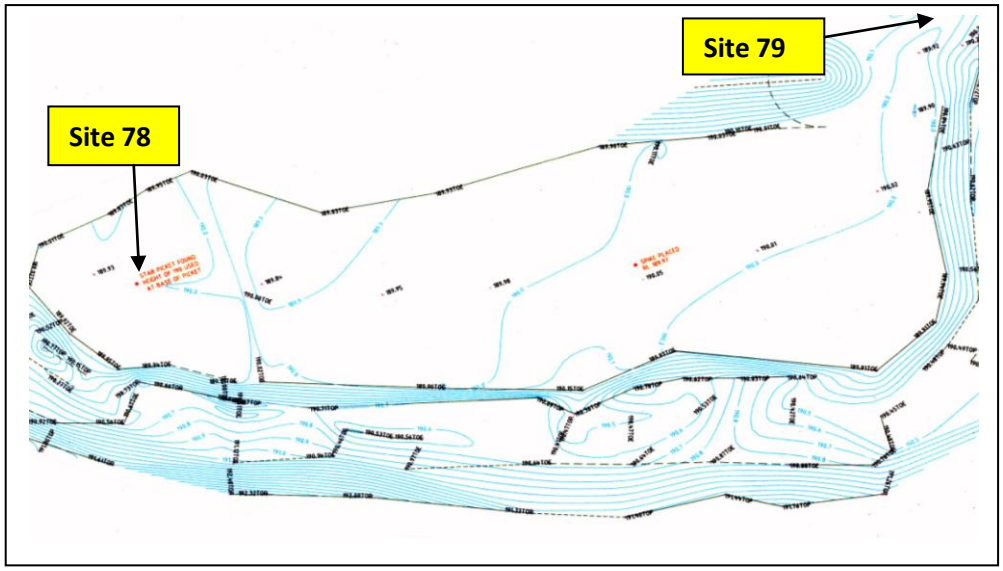
Survey work by David Measki (2012) Contour Interval 0.1 metres.



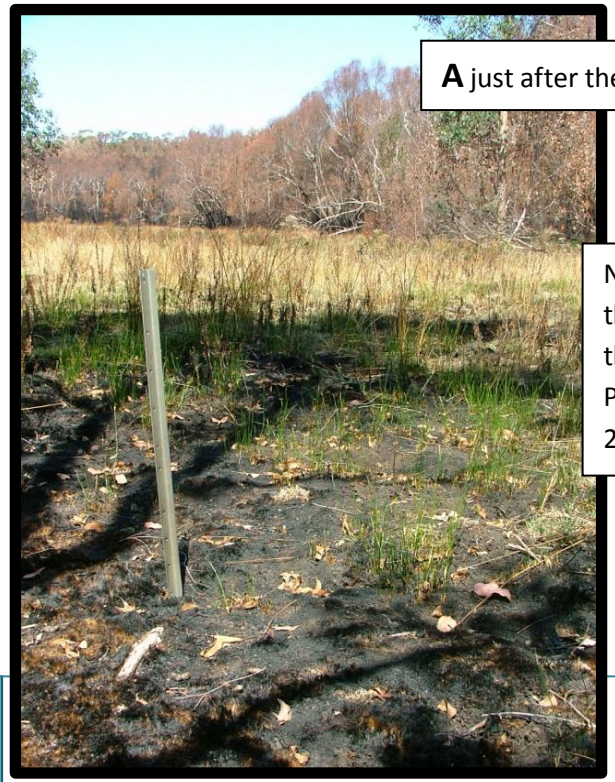
Cross section above, A – E.

David Measki set his starting point at the base of the star picket of Site 78 based on Carr and Muir's.[6] 190 m AHD (Australia Height Datum) 1994 level calculation. Harry Reed. 2012, determined that a point 12m south east of this star picket to be 202.64 AHD (see page 60).





Point A looking east from Site 78.



A just after the fuel reduction burns.

Note the condition of the star picket placed at this site in 2008. Photograph taken in 2012.

B looking east.

On the edge of the tier at **C** looking back at **A**.

C looking east.

On the tier below **E** before the fire reduction.

Point B looking south onto the tier to **CD**.

On the tier at **D** looking north to **CB**.

Carr and Muir[6] made a number of recommendations that included:

1. *A carefully designed monitoring programme involving the establishment of permanent plots should be implemented in areas of hydrologically sensitive vegetation, with emphasis on significant communities and sites, to:*
    - *Gain a greater understanding of ecological tolerances of species and communities with regard to seasonal/annual hydrologically fluctuations (i.e. contribute to baseline data);*
    - *Identify structural and/or floristic changes which occur as a result of lowered water tables over the medium to long term (i.e. decades). This would require control plots to be set up in floristically similar sites where the water table would remain unchanged, probably in a separate catchment.*

2. *Further investigations should be undertaken into the hydrology of particular vegetation communities and sites of significance. Of particular importance in this regard are two perched swamps (Sb2 and SB5, Map 1) and the position of their catchment boundaries in relation to local groundwater patterns and surface topography*. (Sb2 being the Boomerang Swamp).

None of these recommendations were implemented. Another opportunity missed to put in place recommendations that would assist in the evaluation of environmental impacts from groundwater extraction.

1997

!997 was the end of one of the wettest periods on record.

"In 1996 the total rainfall for Colac was 1129 mm compared to the long term average of 762 mm. For the four years prior to 1996 the rainfall for 1995 was 1067 mm, for 1994 it was 843 mm, for 1993 it was 1077 mm and for 1992 it was 1286 mm, all four years well above the long term average rainfall of 762 mm. The long drought in Colac did not in fact start until 1999 when only 470 mm fell," Roger Blake (pers com).

(Roger Blake was involved in the development of the bore observation network in the Barwon Downs area and features in a photograph on the front page of the 1995 Witebsky et al report.[37] Roger was a director of Exploration and Development Essential Petroleum Resources Ltd and has done extensive work for the Government including work as Roger Blake and Associates, Petroleum and Hydrogeological Consultants.)

1997

At the end of this extremely wet period the top end of the Big Swamp, downstream on Boundary Creek, had dried out and caught on fire when an adjoining wildfire passed through. Up to this time this swamp had defied all attempts to drain it and could never be cleared for agricultural pursuits. It was continually far too wet and swampy. This swamp had never been known to be dry going back 85 years. The Big Swamp is also in the Barongarook High area.

1998-1999

Start of an extended drought. Generally accepted as one of the worst since European settlement.

2001

In 2001 "***Ecology Australia was commissioned to resample the hydrologically sensitive vegetation (documented in 1994) to ascertain potential impacts of the operation of the borefield from which water has been extracted for several years.***"[5]

Barwon Water required a brief report consisting of what was found and a comparison with the 1994 survey results. Twenty four of the original quadrant sites were re-sampled, including the Boomerang Swamp Fine Twig-sedge Sedgeland sites . Recommendations were once again made.

Carr[5] found significant differences in floristic (species) composition and structure at the Boomerang Swamp. Vegetation changes at the swamp included a decline in some obligate wetland herbs and invasion by other species formerly excluded from this previously very wet site. The observed changes in the vegetation composition and structure were clearly the result of decreased moisture availability.

> "***Changes to vegetation floristic composition and structure in two high-quality essentially pristine, undisturbed (by exogenous disturbance factors) environments of apparently closed catchments – swamps containing sedge dominant wetlands – Sites 46, 78 and 79.***"

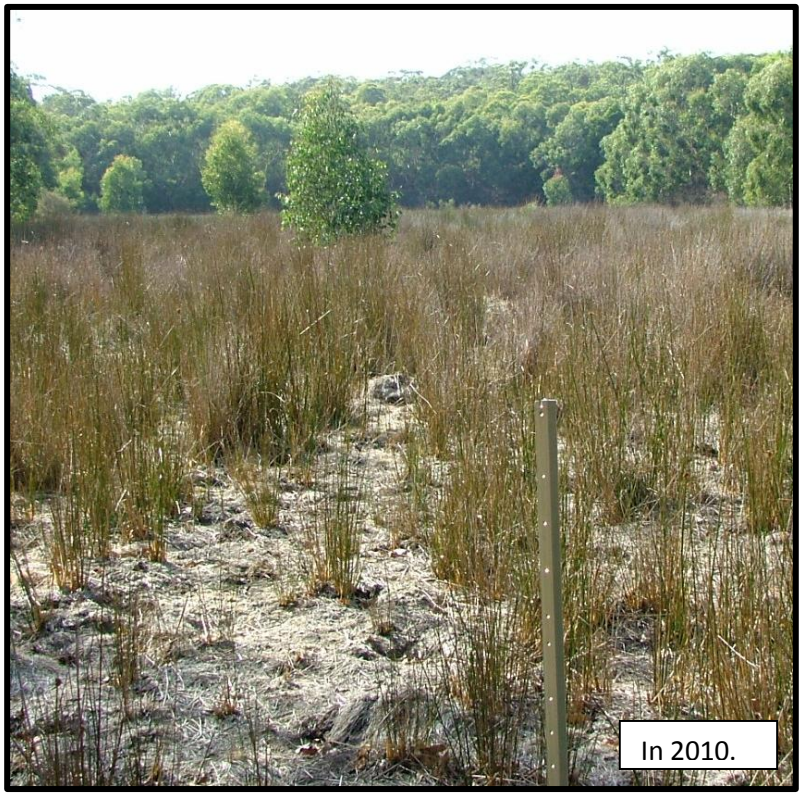
Carr[5]felt that these changes had been brought about by below average rainfall or groundwater extraction or a combination of both.

> "***It seems probable that both factors have caused the vegetation changes as the water table has been considerably reduced as shown by hydrological modelling and monitoring.***"

Carr[5] found the "***very rare Fine Twig-sedge***" sites at Boomerang Swamp had...

- extensive mortality of Jointed Twig-sedge (B. Articulata);
- the virtual disappearance of the aquatic Southern Water-ribbons (Trglochin alcockiae);
- colonisation by a number of non-wetland perennial herbs,; and
- colonisation by E. ovate (to 1 m) and E. viminalis ssp viminalis (to 2.5 m) seedlings and saplings not previously recorded. Melaleuca squarroosa was observed as a coloniser and this may also be actively recruiting.

These significant changes in the Boomerang Swamp, a swamp that previously supported only herbaceous perennial sedge- dominated vegetation, was attributed to the drying out of the previously waterlogged and anaerobic soils. The boundary between the sedge dominated swamp and the surrounding forest noted in the 1994 reporting period, was no longer sharp and pronounced. The invasion or colonisation of non-aquatic and non-amphibious herbaceous plant species and exotic weeds that cannot tolerate seasonal or permanently wet conditions, were now noted in the 2002 report. This changing trend in vegetation was seen as a "...***very clear indication that in recent years waterlogging of the root zone had declined, enabling colonisation of species that would otherwise be unable to survive in the formerly waterlogged environment.***" Boomerang Swamp was drying out and in decline as a site of State significance.



Eucalyptus colonisation in the dry swamp looking east over the marker for Site 78.

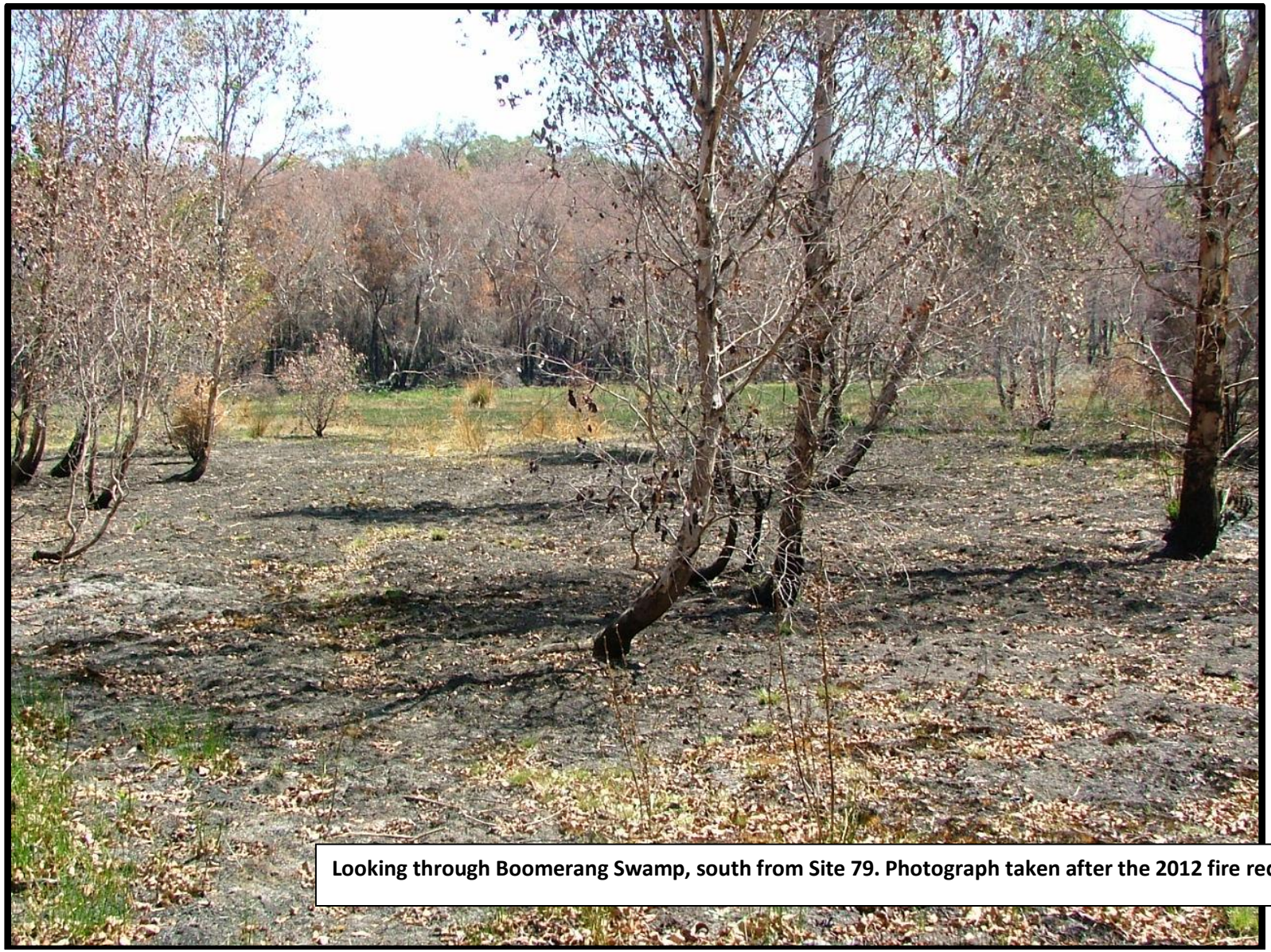
Photograph 2.

This photograph is looking west towards Site 78 in 2012.

Photograph 1.

Photograph looking south over the picket marking Site 79, 2012.

The star pickets were placed at these sites in 2008 two decades after being recommended. Colonisation from eucalyptus trees is quite evident.



Looking through Boomerang Swamp, south from Site 79. Photograph taken after the 2012 fire reduction burn.

The 2002 Carr[5] report mentions that Greg Hoxley (Sinclair Knight Merz) who was involved in hydrological modelling of intake areas, was asked to comment on possible explanations for the reduction of water availability to two other swamp sites that had been recently surveyed. Hoxley was not asked to comment on the Boomerang Swamp sites.[)5)]
In response to these two other sites Hoxley is quoted below.

From the hydrological modelling we infer the following:

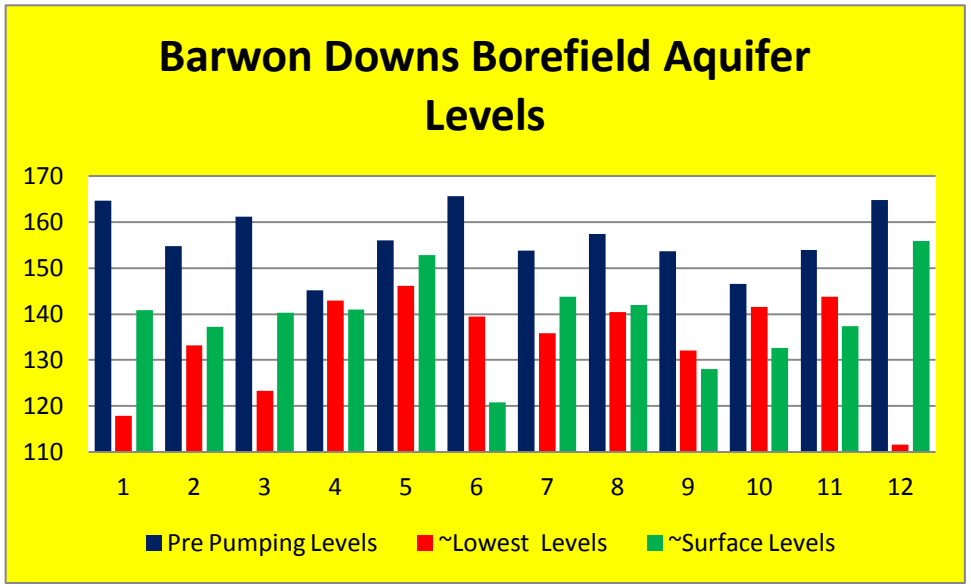
- ***Climatic conditions in the period 1996-2000 have resulted in lowering of regional groundwater independent of pumping. At Site 25 groundwater drop without pumping was modelled to be 1.22 metres. At site 46 groundwater drop without pumping was modelled to be 3.02 metres.***
- ***Groundwater pumping over the period 1996-2000 has resulted in the groundwater at the two sites being lower than would be the case without pumping. At site 25 the additional groundwater lowering as a result of pumping was modelled to be 8.5 metres. At site 46 the additional lowering as a result of pumping was modelled to be 0.42 metres.***

(Interestingly Site 25 was not even surveyed in the early 2000s sampling because it was deemed inaccessible)

If monitoring of the earth structures above the deep water aquifer were being monitored as recommended in 1986 Hoxley would not have had to rely on hydrological modelling nor would he have had to draw inferences to reach the conclusions as stated above. Much, if not all of the guess work could have been eliminated and definitive statements made.

The climatic drought conditions continued for many more years as did the intensity of the groundwater extraction. Bearing in mind these influences, if Hoxley had been asked to comment again in 2006, it would be reasonably safe to assume that he would have concluded that the lowering of the groundwater table in the area had dropped considerably more. The following graph of artesian bores that Barwon Water has been monitoring depicts 12 artesian observation bores in the Barwon Downs Borefield area of influence that have been dramatically lowered over the period of groundwater extraction. Several of these bores were sunk after considerable groundwater extractions had taken place and one can only guess at the overall drop in their levels.

Other bores hydrographs can be seen on pages **25, 29** &**30** and in Appendix Two, pages 113- 118.



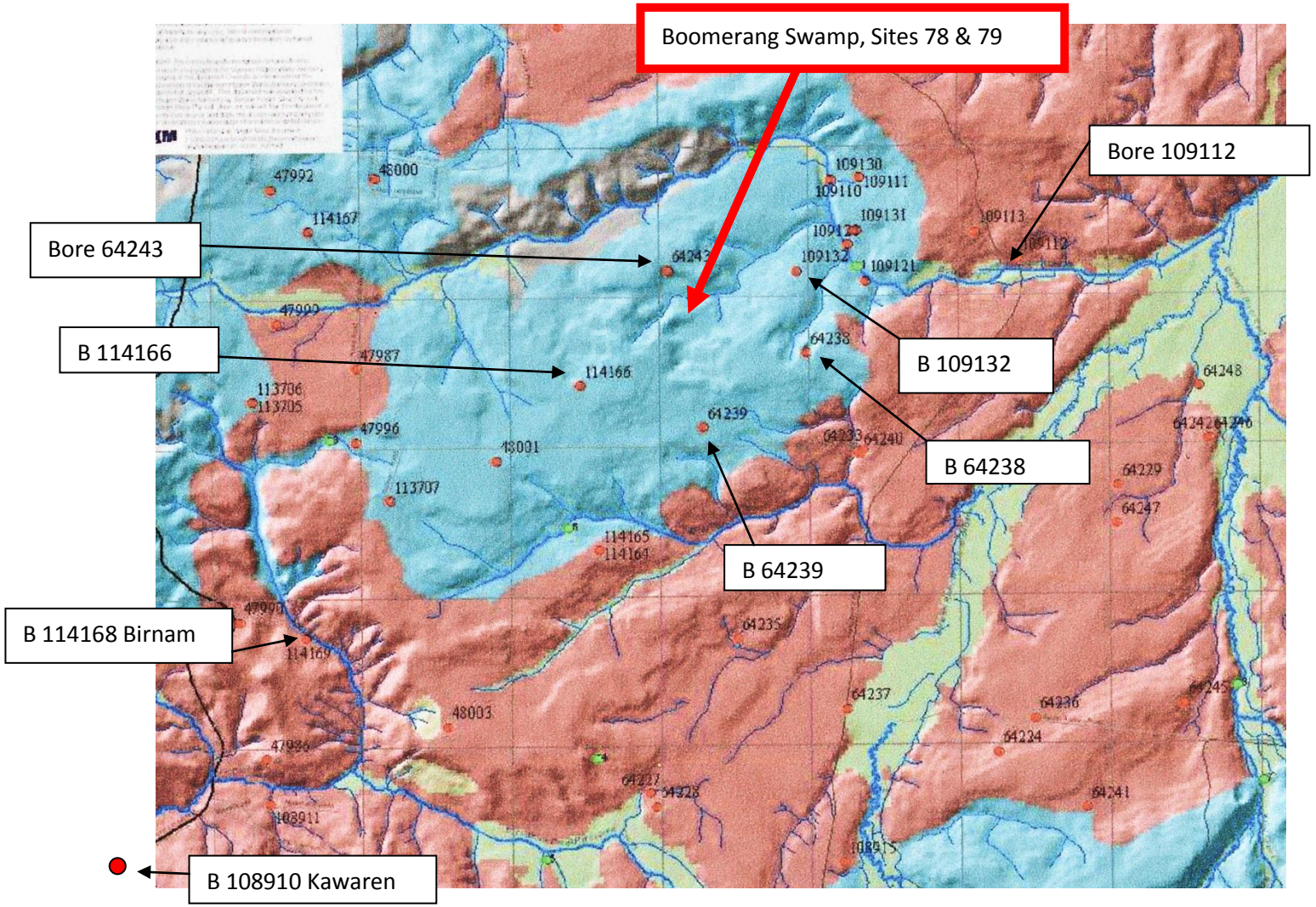
Data Source: Barwon Water (2008) and Vicwaterdata website (2012).

These 12 observation bores located under the influence of the drawdown from the Barwon Downs Borefield [17] all show significant lowering of their water-tables.

However, a totally different picture emerged from 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***."[11] This report states that the regional groundwater is declining generally 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 60 metres at the extraction point.

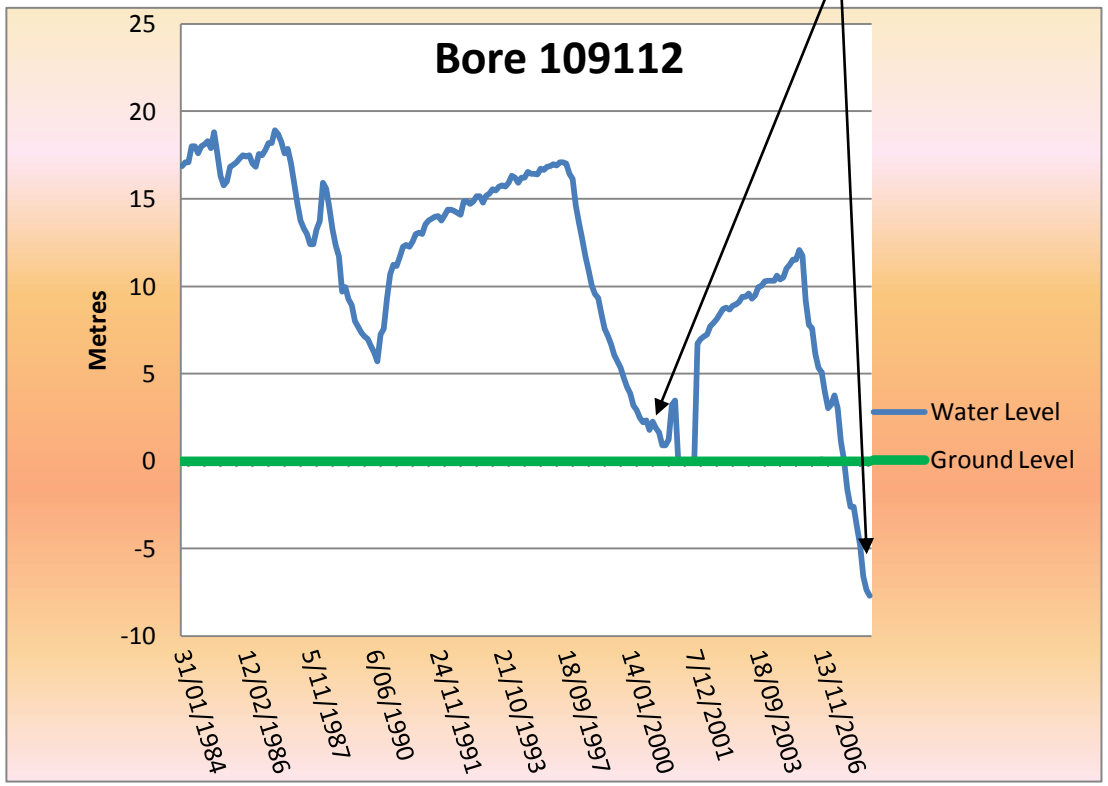
In a Southern Rural Water November 2012, Second Report, three neighbouring Groundwater Management Areas were stated as having groundwater declines ranging from nil and stable up to 4 metres drop for the 15 year period 1997-2012. This report made no comment on the decline in the Gerangamete Groundwater Management Area (GGMA). The GGMA is surrounded by the other GMAs reports.

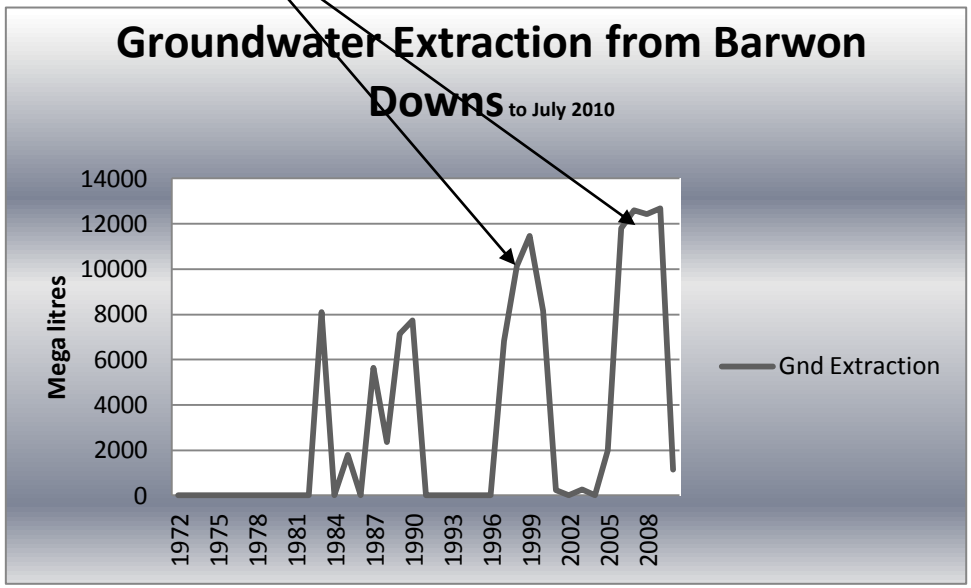
Observation Bore Locations and Boomerang Swamp.



Bore 109112 (Yeo 21) used to be artesian squirting approximately 18 metres into the air.

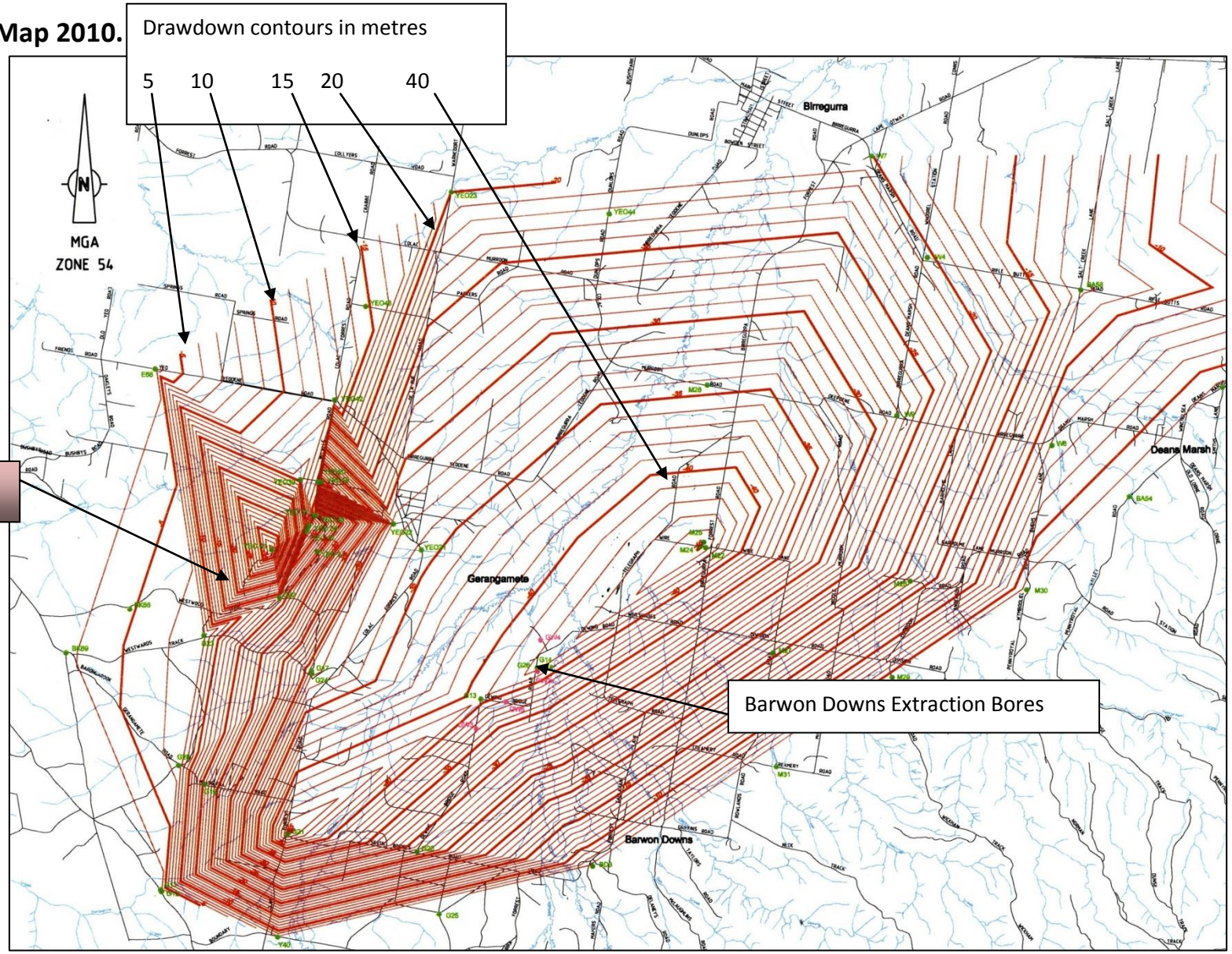
The trends in these graphs are inversely opposite. The groundwater levels drop when the extractions are taking place.





This scenario is repeated throughout the area of drawdown influence from the Barwon Downs Borefield (see the next page for the extent of the influence as far out as Barwon Water will provide the data.)

Residual Drawdown Map 2010.

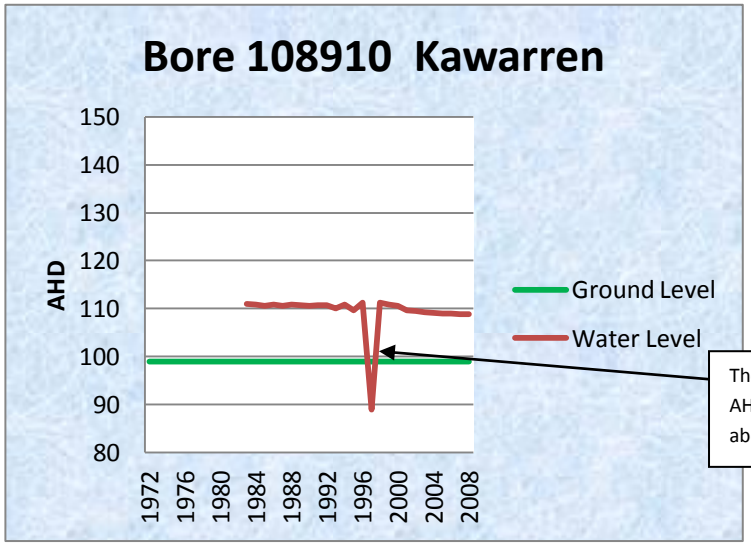


Map Source: Barwon Water.[2]

In Contrast the Kawarren Borefield Area in the South West Victoria with no groundwater extraction exhibits little impact

The Birnam Station and Kawarren artesian observation bores that verge on and are reported as outside the area of drawdown from the Barwon Downs Borefield (see page 24), have maintained relatively stable water-table levels throughout the same period. This confirms the findings of the 2006 Department of Sustainability & Environment report that drawdown in the south west region should be in the order of 10 cm a year.

Bore 109810 (Birnam) and Bore 114168 (Kawarren) in the Kawarren/Gellibrand area, are artesian. There is a distinct difference between the water table graphs of these bores, where there has been negligible groundwater extraction, to the ones in the Barwon Downs area where there has been significant groundwater extraction. These two Kawarren bores have shown little effect from the worst drought on record.



This bore is in the Kawarren/Gellibrand aquifer area. **Source:** DSE Vic Water Data Website

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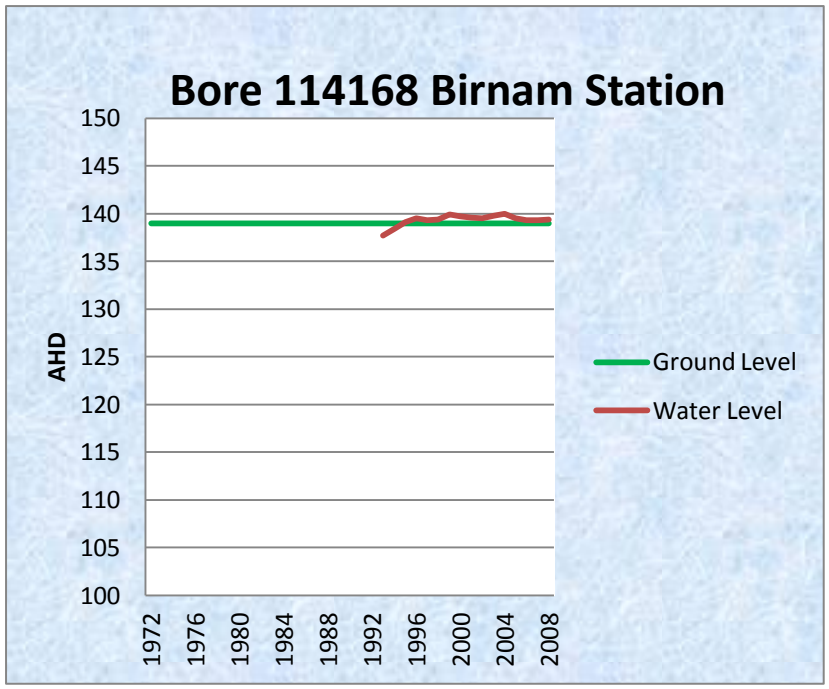
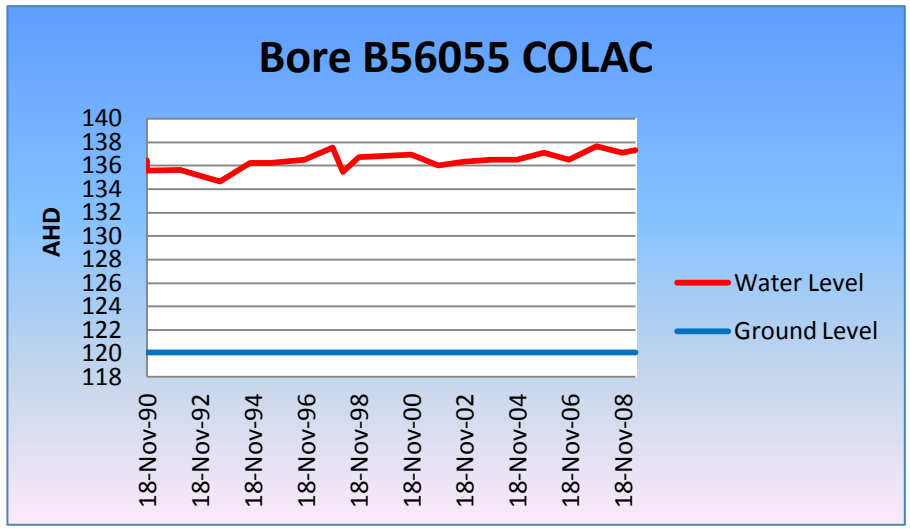
Bore 108910 at Kawarren



A Colac Artesian Observation Bore.

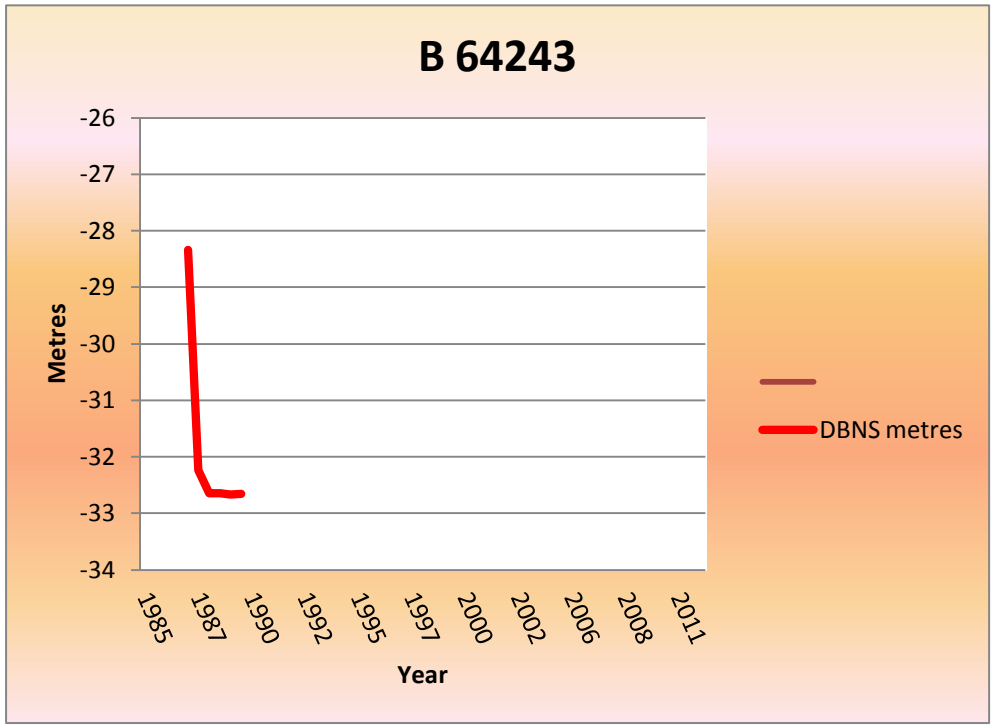


Source **for both these graphs: www.vicwaterdata.net**

The water table level in a Colac Artesian Observation Bore in Colac had actually risen 2 metres.

In stark contrast the bores in the Barwon Downs Borefield area of influence show a significantly marked watertable drop. In some observation bores during extraction periods the drop has been over 60 metres.

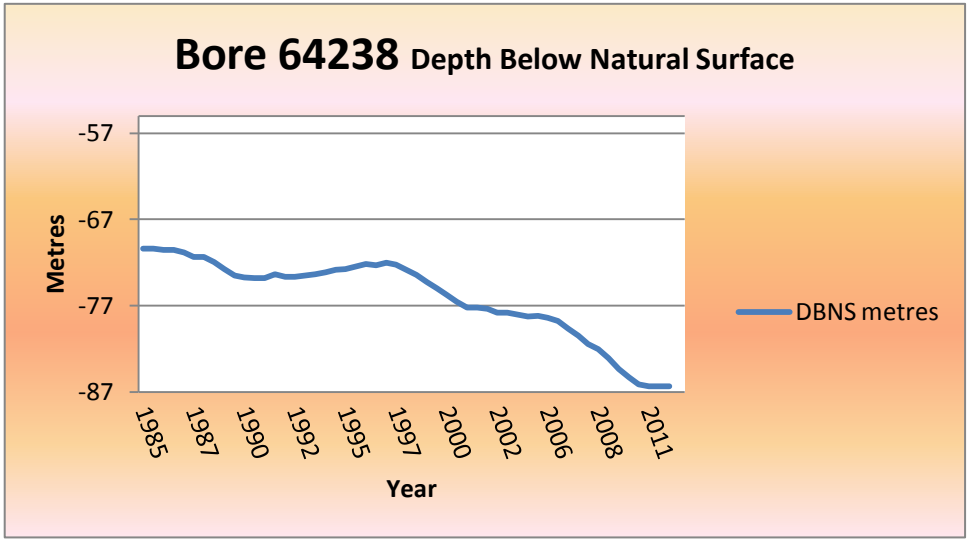
The four hydrographs found on the next page indicate a sharp decline in water table leves. These observation bores are located in a circular pattern around the Boomerang Swamp (see page 24). Southern Rural Water hydrographs for these bores can be found in Appendix Two, page 113.

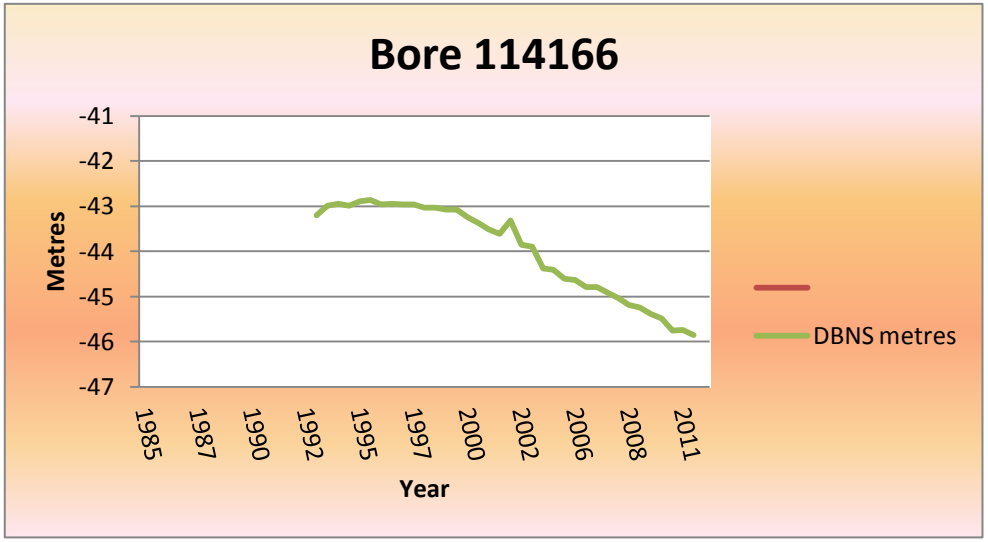


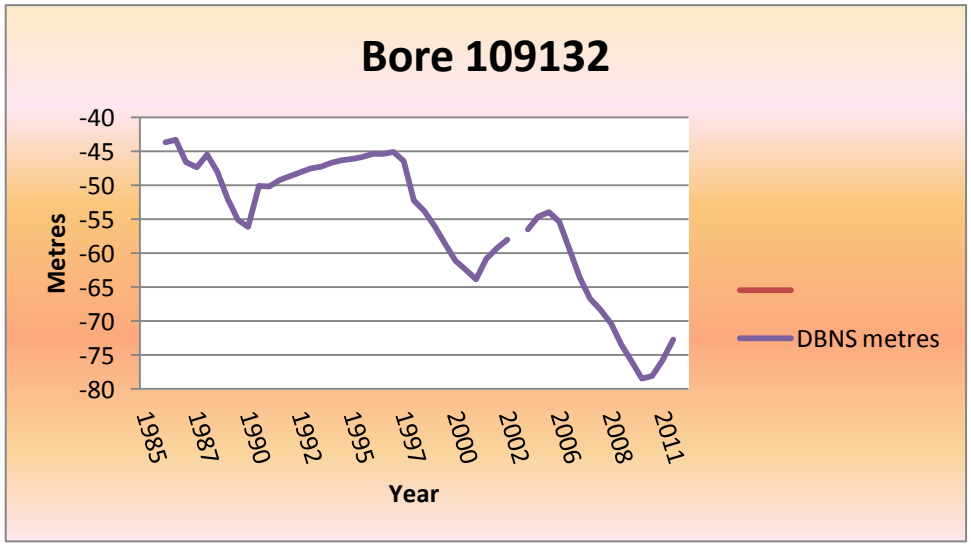
Bore 64243 appears to have been operating for only a short period.

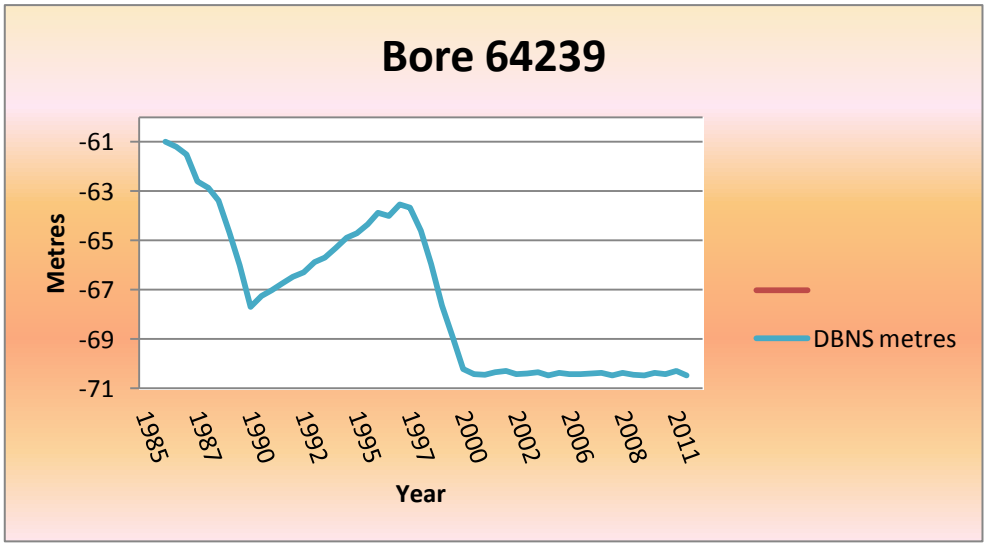
SOURCE: Vic water data warehouse website 2012.

Observation Bore Hydrographs (Drawdown Below Natural Surface - DBNS) **from the Boomerang Swamp locality that are in the area of influence from the Barwon Downs Borefield extractions.** SOURCE: Vic Water Data Warehouse.(Also see Appendix 2 & 3)



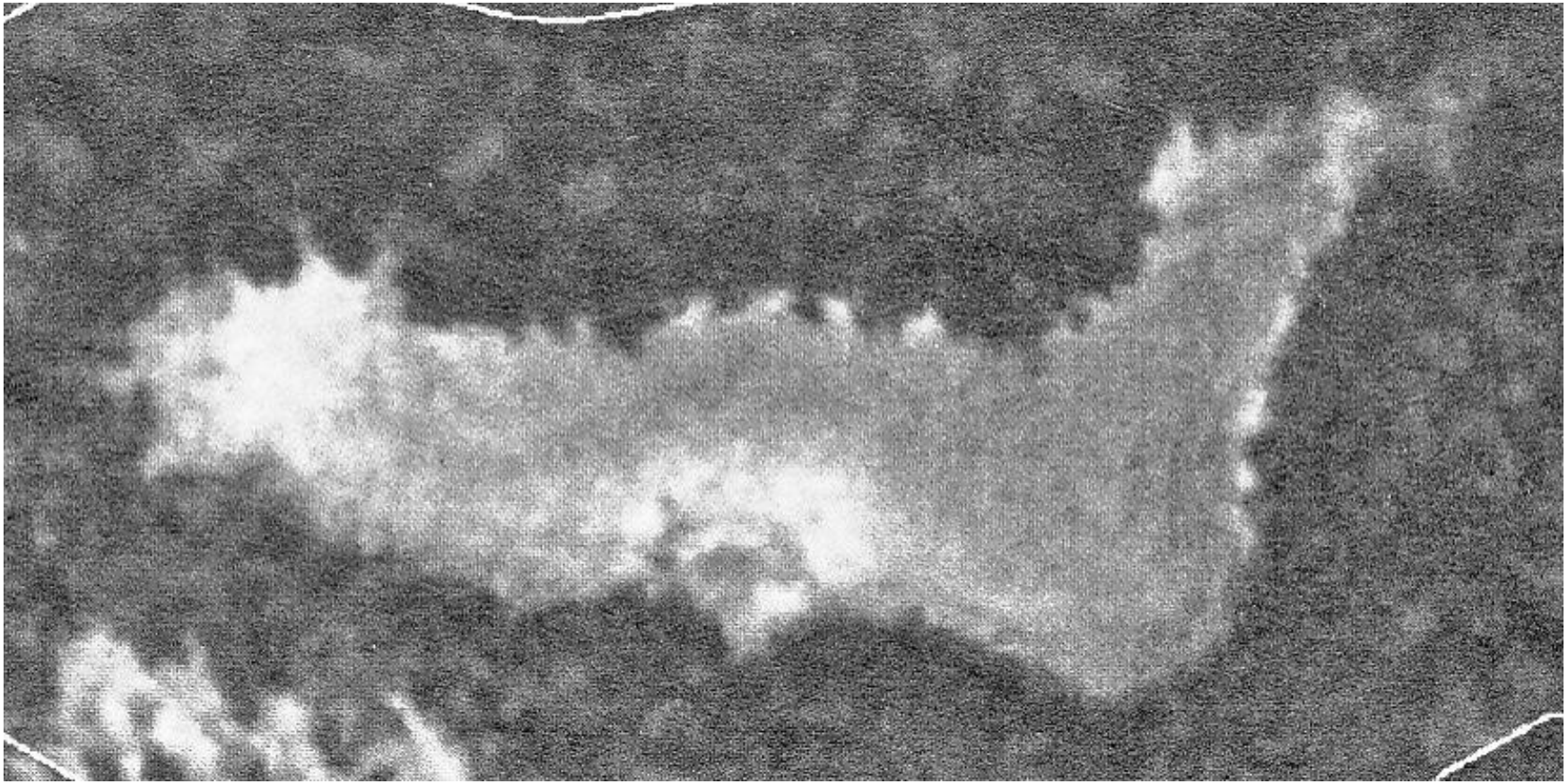


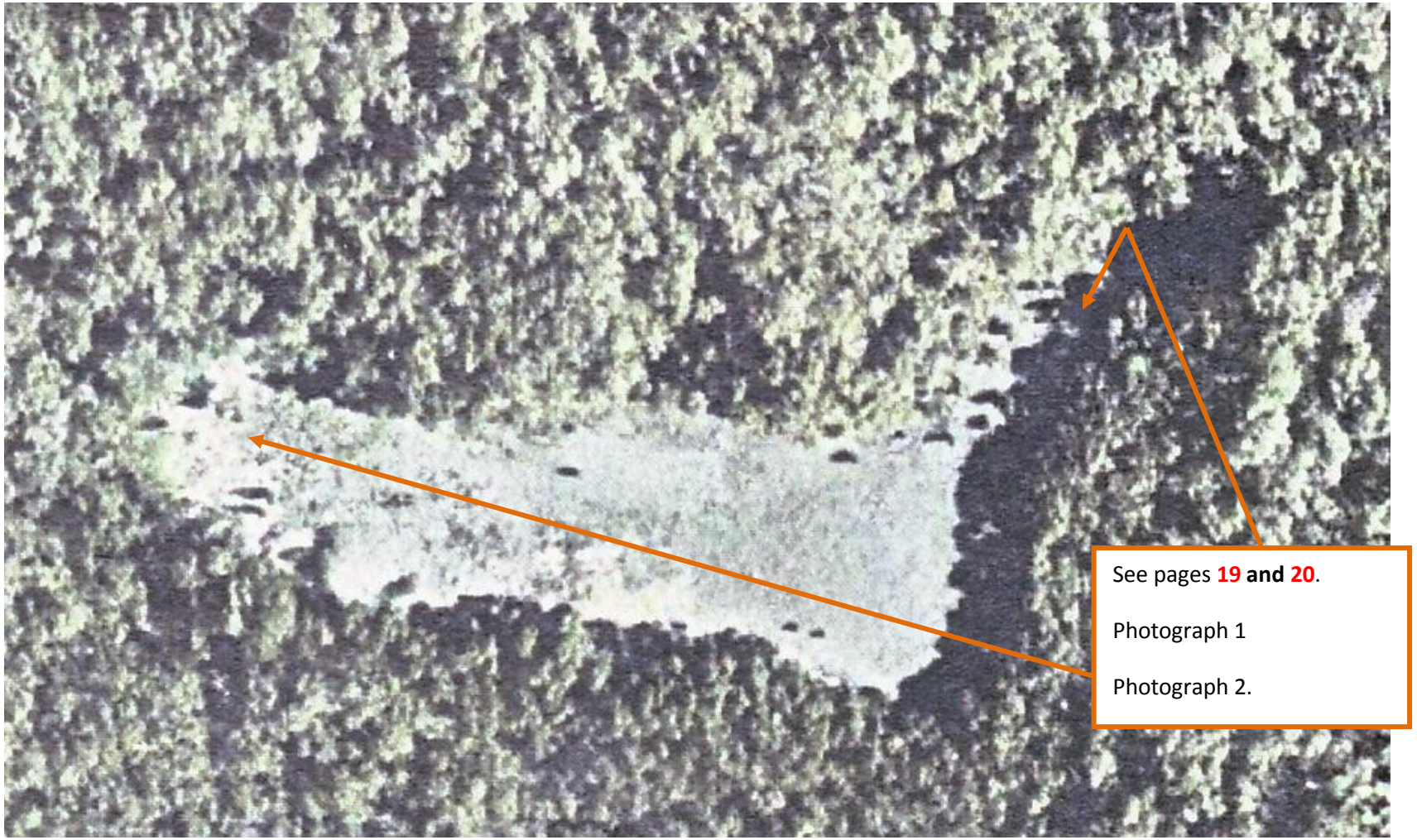




Hoxley was also quoted[5] as saying that the drought of the 1998-2000 period has only been paralleled by a similar drought in the 1920s. Consequently Carr postulated that the colonisation of Sites 78 and 79 by woody and non aquatic herbaceous species, between 1991-2001, could also be a rare episodic event just as in the 1920s period. However, Carr found no evidence of tree stumps in the swamp but did state that any evidence would most likely quickly rot away.

Assuming that the 1920s event parallels the 1990s event it would have taken some time for Boomerang Swamp to be colonised and then some, to return to a water logged state showing no signs of woody vegetation. This aerial photograph taken in 1947 appears to shows no indication of woody vegetation having ever been present in the swamp.





This aerial 2007 photograph shows distinctly the colonisation of trees into the swamp. It seems most unlikely that the 1920s and 1990s can be classed as parallel episodic events. These trees are well established and some years old.

In the recommendation section of the 2002 Carr report[5] the following comments are applicable to Sites 78 and 79:

> "***The following recommendations are made to further investigate potential hydrological impacts on vegetation from groundwater extraction.***
>
> - ***Convene a meeting with staff of Barwon Water, Sinclair Knight Merz (hydrological modellers), Ecology Australia Pty Ltd and other relevant parties to discuss implications of the findings of this study...***
> - ***In consultation with relevant parties, design and implement long-term vegetation and hydrological monitoring program. Pending further resolution, this should at least involve:***
>   - ***Selecting a range of sites carrying hydrologically sensitive vegetation with permanently-marked replicated plots of suitable size which would be monitored at a pre-determined frequency...***
>   - ***Monitoring of floristic composition and cover/abundance of plant species using a high-resolution scale...***
>   - ***Establish, where possible, control plots in comparable vegetation at sites as near as possible in the Otway Ranges which have not been subjected to hydrological modifications. monitoring of water table at the sites where vegetation is monitored.***

Although the wording of Farmar-Bowers's 1986[14] recommendations differ from the ones made by Carr and Muir in 1994,[6] the intent was almost identical. Most of these very same recommendations, although worded differently once again, are reflected in these 2002 recommendations.

Mid 2002

The 20 August 2002 report to the Barwon Downs Licence Renewal Panel included some serious concerns regarding the sedge land swamp areas, [33] that included Boomerang Swamp.

- There was a need to determine the predicted/monitored extent of aquifer drawdown,
- the rates stated in current calculations may be misleading,
- the effect of pumping may be highly variable and may require more intensive monitoring of bores close to these areas,
- there is general concern regarding the compound effect on sensitive swamp habitats through repeated and prolonged lowering of water table, and
- if determined that the drawdown is impacting then options for supplementary wetting could be explored.

LATE 2002

1. At the Barwon Downs Licence Renewal Panel, 8 November 2002, it was reported that the Ecology Australia flora "***Consultant expressed on-going concern over three swamp areas (Site 46, Pithy Saw-sedge Sedgeland), (Site 78, FineTwig-sedge Sedgeland) and Site 79 Jointed Twig-sedge Sedgeland).***"
   The minutes of this meeting also included;
   - "***The issue of monitoring draw down at the swamp sites requires further clarification from Hydrologist and if necessary installation of a monitoring bore."***
   - ***"Focus surveys on sites 46, 25, 78 and 79."***
   - ***"Facilitate meeting between consultant and Barwon Water & SKM to discuss hydrological implications on survey work***."

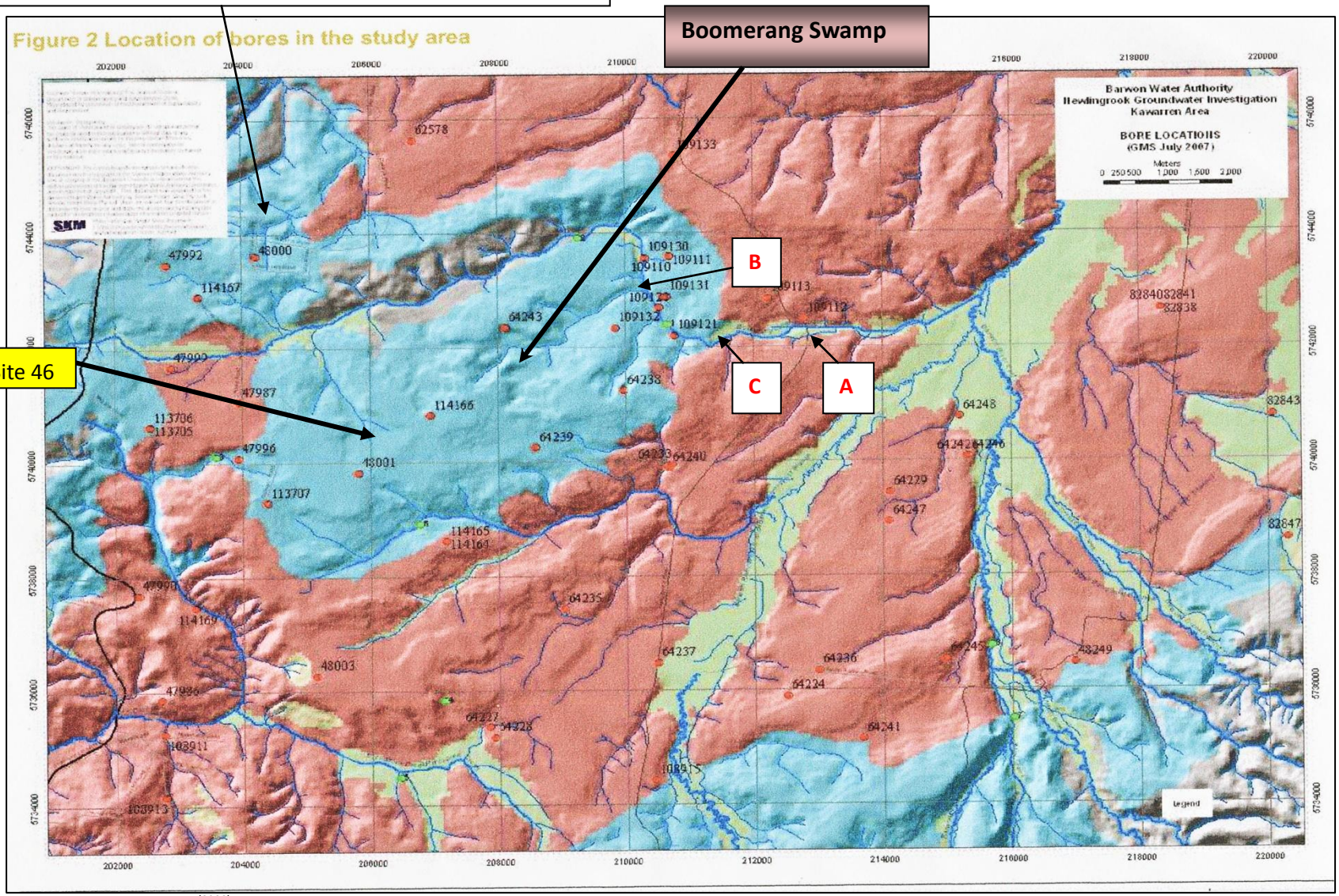
2. A report to the Barwon Downs Panel – Groundwater Technical Group, 12 November 2002, included the following:

Issue raised	Relevant to Licence Assessment	Potential Importance	Knowledge Level	Investigations required to Improve Knowledge	Monitoring	Additional Monitoring Required	Comments/Conclusion
Barongarook High Impacts	Yes	High	High	No	Yes	No?	Impacts need to be remedied to allow pumping from wellfield.

It is quite clear from this table that the Review Panel had considered the Barongarook High area and had found the potential importance of impacts to be high but at the same time believed there was sufficient knowledge available to remedy any impacts. Most alarming was this notion being expressed that there was no need to expand this knowledge base.

Looking at the map on the following page it is quite obvious that the Boomerang Swamp lies well within the Barongarook High intake area of the deep water aquifer (shown in blue), the very aquifer the Barwon Downs Borefield extracts it water from. It would appear that the concerns being expressed up to this period, in regard to the connectedness of the Boomerang Swamp with the deep water aquifer, were well founded. It would also appear the concern, that there did not appear to be enough known about the Fine twig-sedge Sedgeland's status, fell on deaf ears of the decision makers.

Outcropping at the surface of the deep water aquifer – in blue.



Source; SKM 2009 report[(2009)]

SOME TIME LATER

Sometime between the 12 November meeting when it was expressed that no further investigations were required, a meeting of the Barwon Downs Groundwater Renewal Panel on 9 January 2003 expressed the exact opposite. A draft licence conditions document included the following as part of Schedule 3, and indicated that the concerns being expressed were indicative that more knowledge was required. Therefore, it seems logical to suggest that one group was not aware of another group's decisions and recommendations.

7. WETLAND PROTECTION

7.1 General

A. Within 18 months of the commencement of this licence, Barwon Water must demonstrate to the satisfaction of the Authority that the wetlands at Flora Site 46, and Flora Sites 78 and 79 are not dependent on groundwater discharge from the regional water table.

B. If the Authority is not satisfied either or both wetland referred to in A above are not dependent on groundwater discharge from the regional water table, Barwon water must:

(a) provide an alternative water supply to the respective groundwater wetland referred to in A above, from the time of commencement of pumping at the borefield, until

(b) groundwater levels can be shown to have recovered above lowest underwater ground surface level demonstrated to the satisfaction of the Authority that the inflow of natural groundwater discharge removes the need for the alternative supply referred to in (a) above.

At some time in the Renewal Panel process it must have been decided that there was no dependence of Boomerang Swamp on groundwater discharge from the deep water aquifer influencing the Fine Twig-sedge Sedgeland as this Section 7 above, was deleted from the final copy of the licence conditions.

These swamps may not have been in direct connection and receiving discharge from the deep water aquifer but there can be no doubt that the Boomerang Swamp is located in an area of the unconfined deepwater aquifer that had been significantly drawdown when this decision was made.

EARLY 2003

At the Barwon Downs Groundwater Renewal Panel meeting 9 January 2003, Geoff Carr (Ecology Australia) and Greg Hoxley (SKM) presented reports. The points made that are relevant to Boomerang Swamp (sites 78 & 79) are as follows:

Key points from Geoff Carr re; flora issues

- *Inherent limitations of vegetation surveys in that vegetation change may take years to manifest there is always some natural fluctuation.*
- *Reviewed 24 sites during 2001/02 and only four sites had "significant change; sites 25, 46, 78, 79.*
- *Perched swamps at site 78, 79 & 46 contained water in 1994 survey.*
- *Vegetation in perched swamps at sites 78, 79 & 46 is rare and survive in anaerobic conditions. Lower water levels have resulted in less water logging of roots which has been more conducive to invasion by non swamp related species.*
- *Recovery of perched swamp vegetation is likely to occur when water levels return ie; water logging of roots will kill species not associated with swamps and allow re-colonisation of swamp vegetation.*
- *Recovery likely at all sites if conditions return as "these species are really tough', particularly the sedges.*

Key points from Greg Hoxley – SKM

- *Groundwater levels were at peak levels in 1993/94 when previous flora surveys conducted.*
- *Since 1994 rainfall deficit has been extraordinary in comparison with last 100 years.*
- *Shallow (local systems) largely not affected by groundwater pumping.*
- *Flora sites 46, 78, & 79 are not connected to regional water table – they are perched above the highest level of the water table. e.g site 46 is 30m above regional water table and therefore the vegetation is not affected by the pumping.*
- *Water levels at Flora sites 46, 78 & 79 should recover faster than Regional System.*

Outcomes and future actions

- *Flora sites 46, 78 & 79 are not connected to Regional Groundwater Table therefore only require shallow (2-3m) hand augured monitoring bores at two sites. Also gauge to measure surface water levels.*(Never been done)
- *Monthly monitoring of Regional water table to include monitoring of shallow watertable to demonstrate non-conductivity.*(Never been done)
- *For sites 46, 78 & 79 there needs to be agreement who monitors flora when Regional groundwater system has returned to normal given that the change in vegetation is not related to Barwon Water activities.* (Never been done)
- *Flora monitoring sites need to be clearly marked.* (Not done until 2008 during the 2008-09 flora survey)

From Roger Blake's research (see page 18) the rain deficit did not happen in the area until 1999, not 1994 as Hoxley stated. Having lived in the area since 1959 I can confirm that personal experience supports Roger Blake's research. Also, the Barwon Water Flora Study 2008[29] provides similar confirmation when it states quite clearly,

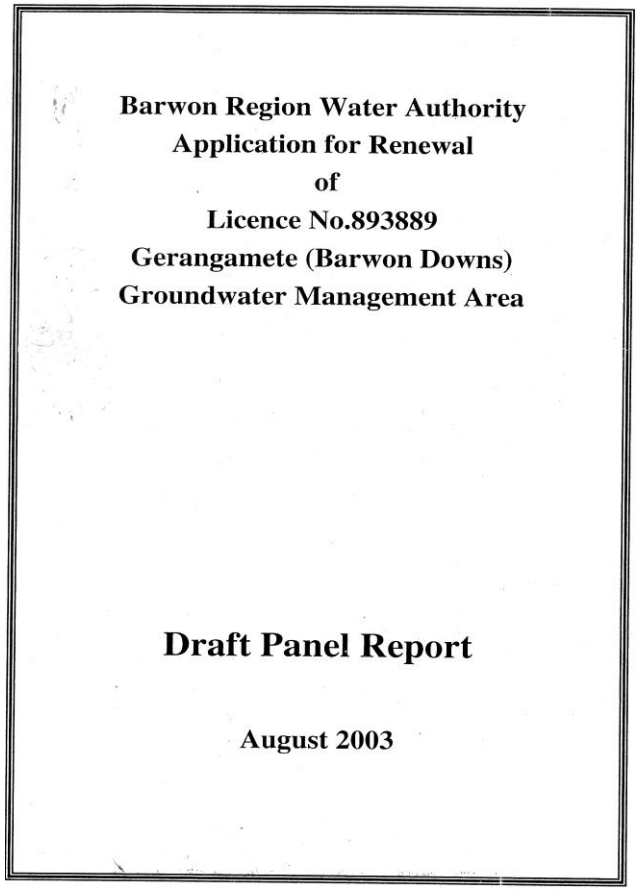
"...***showed signs of moisture stress, indicating the impacts of declining rainfall over the previous 11 years.***" 2009 minus 11 years is 1998.

This places the start of the drought in this region no earlier than in the very late 1990s.

After good winter rains in 2010 and 2011 the Boomerang Swamp had not recovered as quickly as Hoxley predicted, as these photographs show in the middle of winter June 2012.

August 2003

In the August Draft Panel Report 2003 there still appeared to be considerable concern with the Boomerang Swamp wetlands.



Barwon Region Water Authority
Application for Renewal
of
Licence No.893889
Gerangamete (Barwon Downs)
Groundwater Management Area

Draft Panel Report

August 2003

LICENCE CONDITION: Barongarook High Wetland Protection

Background

Important Wetlands have been identified on the BH at Flora Site 46 and at Flora Sites 78&79
Present indications are that the regional groundwater level at Site 46 (as shown by bore BK 69) is well below the ground level of the site and the wetland is perched
The regional groundwater level at Sites 78&79 are also thought to be below the level of the wetland, however there are no monitoring bores situated close by
The intention of this condition is to assess whether the wetlands at both sites are in fact dependent on the regional groundwater system
If they found to not be dependent, no further investigation and monitoring at these sites wil need to be undertaken by BW
If they are dependent, the wetlands will need to be protected, which will involve BW providing water for the wetlands and ongoing monitoring

1. Setting Objectives and Prescribing Limits

Objective : Important wetlands on the Barongarook High must be assessed to determine whether or not they are dependent on discharge from the regional groundwater system

Limits: It must be demonstrated to the satisfaction of the Authority that the regional groundwater levels at Flora Site 46, and Flora Sites 78 and 79 are beneath the lowest point of each wetland following full recovery of groundwater levels

2. Monitoring

Prescribing the Monitoring Network

Network Description: A shallow water table monitoring bore must be installed at Flora Site 46 and at Flora Site 78 &79 to a depth of 3 m below the base of each wetland
The shallow monitoring bores must be constructed in accordance with a bore design approved by the Authority
A graduated water level measuring staff must be installed at each wetland
Datum levels for the bore and measuring staff must be determined relative to AHD within a level of accuracy of + or - 10 cm.

Prescribing the Monitoring Activity

Monitoring Description: The shallow bore and wetland levels must be determined quarterly for a minimum period of one year after the granting of this licence and up to a maximum time that the Authority is satisfied the regional groundwater level will not intersect the base of either wetland upon full recovery of groundwater levels

Data Management: Groundwater and wetland water levels must be entered on to a data base within 30 days of recording

Reporting and Review of Monitoring

Reporting: An initial assessment of the degree of dependence of each wetland must be provided to the Authority within 18 months of the commencement of this licence containing:
water level records from the monitoring bores and wetlands
an assessment of the extent to which regional groundwater levels have

	reached their full recovery level an assessment of whether regional groundwater levels may intercept the base of either wetland based on water levels from neighbouring bores monitoring the regional water table
Review Description:	If the Authority is satisfied upon receipt of the initial report that the wetlands site 46 and sites 78&79 are not connected to the regional water table, further monitoring and investigation at the wetlands by BW will not be required If the Authority is not satisfied the wetlands are not dependent on the regional water table, the Authority may require further monitoring and investigation to be undertaken as will be specified by the Authority under this licence If either wetland is found to be dependent on the regional water table the Authority will require BW to provide an alternate water supply for the wetland, sufficient to protect the environmental values of the wetland

Tragically, this "***Barongarook High Wetland Protection***" section was omitted from the final copy of the licence conditions. This decision was based on information that is discussed at a later stage and found to be extremely questionable.

2004

The 2004 - 2019 licence was issued to Barwon Water to extract groundwater from the Barwon Downs Borefield at a rate of 20 000 ML/year with no more than 80 000 ML over any 10 year period and no more than 400 000 ML over a 100 year period. Considering a sustainable extraction rate of 1 600 ML/year was recommended back in the 1980s, and then the Permissible Annual Volume (PAV) was set at 4 000 ML/year in the middle 1990s, these licence limits seemed extraordinary, especially when one of the licence conditions was supposedly designed to protect riparian vegetation in the area of drawdown influence. The licence conditions also aimed at attempting to minimise impacts on the surrounding environment, river/creek flows and other groundwater users.[29]

Why the following flora sites (see next page) were chosen as sites to achieve this beggars belief. In the 2002 survey Site 25 could not be located and as a consequence was not even surveyed. **A*ll of the control sites*** recommended to be included in the 2009 study fell so far inside the area of drawdown influence from the borefield that there is absolutely no way that they could be regarded as control sites.

Sites 78 and 79 had been completely disregarded as sites of any hydrological significance in regard to impacts from the Barwon Downs Borefield drawdown and no longer seemed to be any one's concern or responsibility.

7. PROTECTION OF RIPARIAN VEGETATION

7.1 General

A. Barwon Water must undertake a floral survey at the following sites within 5 years of the commencement of this Licence and thereafter at five-yearly intervals:

a. Flora Site 25 on Boundary Creek (Grid Ref 341441, Mapsheet Gerangamete 7621-3-2);
b. Site upstream of Site 25 (Grid Ref 330456, Mapsheet Gerangamete 7621-3-2);
c. Control sites away from Boundary Creek:
    c.1 (Grid Ref 267421, Mapsheet Barongarook 7621-3-3);
    c.2 (Grid Ref 304377, Mapsheet Gerangemete 7621-3-2);
    c.3 (Grid Ref 299360, Mapsheet Gerangemete 7621-3-2);
    c.4 Survey Site No.22 ,(Grid Ref 303409, Mapsheet Gerangemete 7621-3-2); and
d. Flood plain East Barwon River, EVC - Riparian Swamp Woodland:
    d.1(Grid Ref 392367, Mapsheet Gerangemete 7621-3-2);
    d.2 (Grid Ref 390381, Mapsheet Gerangemete 7621-3-2).

B. Prior to engaging a consultant to undertake a floral survey, Barwon Water must:

a. consult with the Department of Sustainability & Environment regarding suitable consultants; and
b. then obtain the approval of the Authority for the consultant it proposes to use.

7.2 Reporting

Barwon Water must provide to the Authority:

a. within 180 days of completing a floral survey under sub-clause 7.1, a report containing:
    i. the results of the floral surveys; and
    ii. a review of groundwater levels as determined from the bores listed in the Third Schedule that are adjacent to the flora sites; and
b. when it applies for the renewal of this Licence, a report assessing the degree of dependence of riparian vegetation at the sites specified in sub-clause 7.1 on the regional groundwater system, and that includes recommendations for any further work necessary to ensure their protection.

SOURCE: Southern Rural Water, Groundwater Licence No. 983889, Barwon Region Water Authority.

August 2008

In August 2008 it was noted that there were elevated levels of acid in the waters of Boundary Creek at the Colac to Forrest Road Bridge (see page 35, point A). The major source of this acid water was found to be originating from the area known as the Big Swamp or Jurassic Park (see page 35, point C). However, when attempting to find the source of this acid water it was noted that a tributary of Boundary Creek (see page 35, point B) upstream from the Big Swamp, also had elevated levels of acid water. Due to the work being done to gain a full understanding of the environmental impacts taking place in the Big Swamp, this minor flow of acid water in this tributary was not revisited until sometime later.

When doing a Google Earth search of the area it was noted that at the headwaters of one of the tributaries of Boundary Creek there was an area that looked like a boomerang and appeared to have similar aerial photograph characteristics as witnessed in the Big Swamp. A further search of documentation and visitation to the site eventually lead to the recognition of the Carr and Muir[6] Sites of 78 and 79. Because of the shape of this swamp it was given the name Boomerang Swamp.

The following photographs were taken over a period of two years of visits up to the time that this area and the swamp were burnt as part of a fire reduction effort in early 2012.

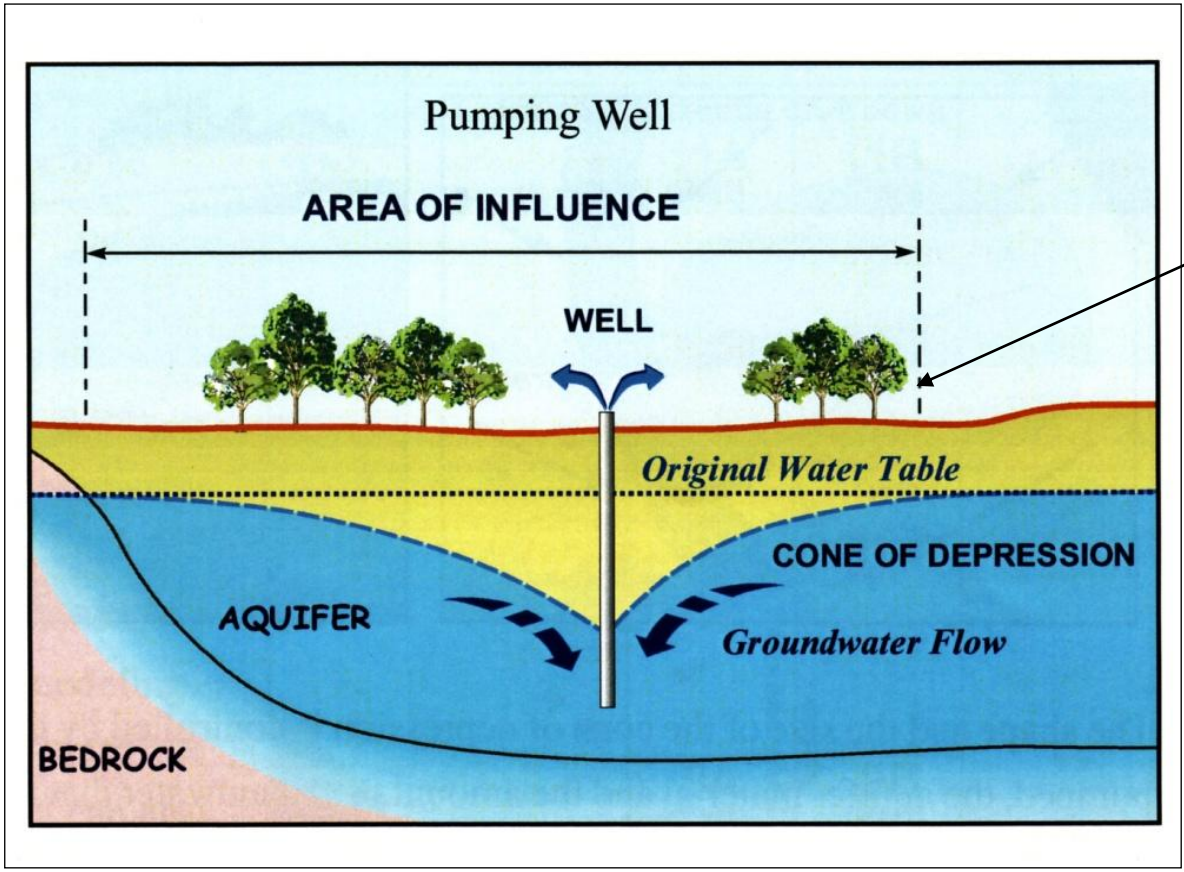
Since visiting Boomerang Swamp in 2009 it has always been dry.

Even after 2 years of winter rains the swamp remained dry.

The Point of Zero Drawdown.

The map on page **26** shows the drawdown impact underneath the Boomerang Swamp to be between 5 and 10 metres. This area has been impacted in this way as far back as drawdown maps have been prepared. Unfortunately though, Barwon Water's drawdown maps do not show all of the area of influence, in some instances stopping at the 5 metre drawdown.

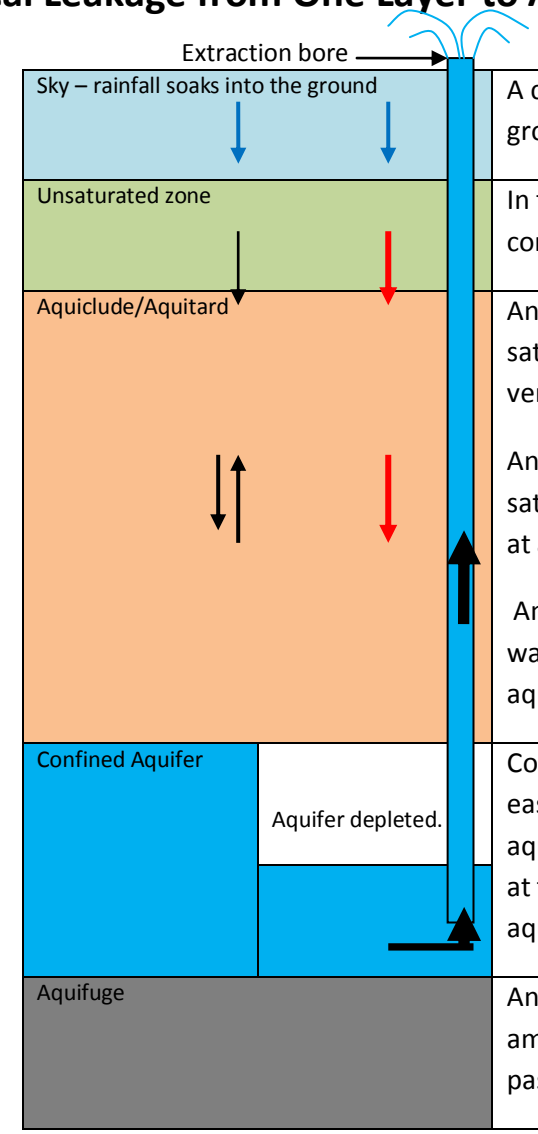
The impacts from a cone of depression goes out to the point of zero drawdown. This diagram below from the Australian Centre for Groundwater Studies highlights this fact and if the Boomerang Swamp was to be marked in it would be within the cone of depression and a considerable distance inside the zero area of influence.



Any site located inside this zero point of influence will suffer from drying out as the water in the upper layers leaks down to replenish the depleted aquifer below. Any drying out as a consequence of vertical leakage may take some time to eventuate and will depend on rainfall and the amount and duration of ground water extraction.

SOURCE: Australian Centre for Groundwater Studies, Blackwood South Australia

Vertical Leakage from One Layer to Another.



Sky – rainfall soaks into the ground	A certain amount of rain falling soaks into the ground.
Unsaturated zone	In the gaps between particles of soil this zone contains both air and water (see page **48**).
Aquiclude/Aquitard	An aquitard is a confining bed but can be saturated and can allow water to move slowly vertically through it . An aquiclude is a confining bed that can be saturated allowing little water to pass through it at a greatly reduced speed. An aquitard and aquiclude are difficult to extract water from and as a consequence are not called aquifers.
Confined Aquifer / Aquifer depleted.	Confined aquifers are usually full of water and easily give large amounts of water. These aquifers are recharged where they are exposed at the surface and from leaky confining beds or aquitards above.
Aquifuge	An aquifuge is a layer containing minute amounts of water and doesn't allow water to pass through easily e.g. solid granite.

The blue and black arrows indicate movement of water in an unexploited system.

The Blue and red arrows indicate the movement of water when the water in the deep water aquifer is being extracted faster than it can be replenished.

46

In 2012 when referring to the lower aquifers, namely the Dilwyn, Mepunga and Pebble Point aquifers, a Corangamite Catchment Management Authority document[9] states,

"***The lower aquifers are mainly recharged from leakage from the overlying aquifers.***" Vertical leakage.

The lower aquifers are the ones that the Barwon Water Borefield is extracting water from and this statement reinforces the commonly accepted notion that there will be vertical leakage of water from those geological structures above.

Table 2 Aquifers and Aquitards[1] present in Study Area

Geological Unit	Description	Type	System
Quaternary Alluvium	Sands, silts and gravels.	Aquifer (minor)	Minor surficial aquifer restricted to river and creek channels
Gellibrand Marl	Calcareous silty clay and clayey silt. Fossiliferous.	Aquitard	Mid Tertiary Aquitard (MTD)
Clifton Formation	Calcarenite with marine fossils and minor quartz and limonite sands	Aquifer (minor)	
Narrawaturk Marl	Calcareous mudstone with thin carbonaceous beds, sand beds and fossiliferous beds	Aquitard	
Mepunga Formation	Medium to coarse grained quartz sand with some carbonaceous clays and silt layers	Aquifer	Lower Tertiary Aquifer (LTA)
Dilwyn Formation[2]	Carbonaceous, sandy clays and silts, with some quartz sand and silty sand beds, and minor gravel. Coal and carbonaceous clays also occur in this unit.	Aquifer	
Pember Mudstone	Clays, silts and fine grained sand with carbonaceous, micaceous and pyritic horizons.	Aquitard (minor)	
Pebble Point Formation[2]	Fine-grained sand with carbonaceous silt and quartz pebble beds. This unit is an equivalent to the Moomowroong Sand Member, Wiridjil Gravels that occur in the Gellibrand sub-basin to the south west of the study area.	Aquifer (minor)	
Bedrock	Sandstone, siltstone and mudstone with feldspar and quartz grains, well-bedded and consolidated.	Aquitard	

1. Aquitards are shaded grey
2. These geological units may also be referred to as the Eastern View Formation

SOURCE; Barwon Downs Flora Study 2008[(29)]

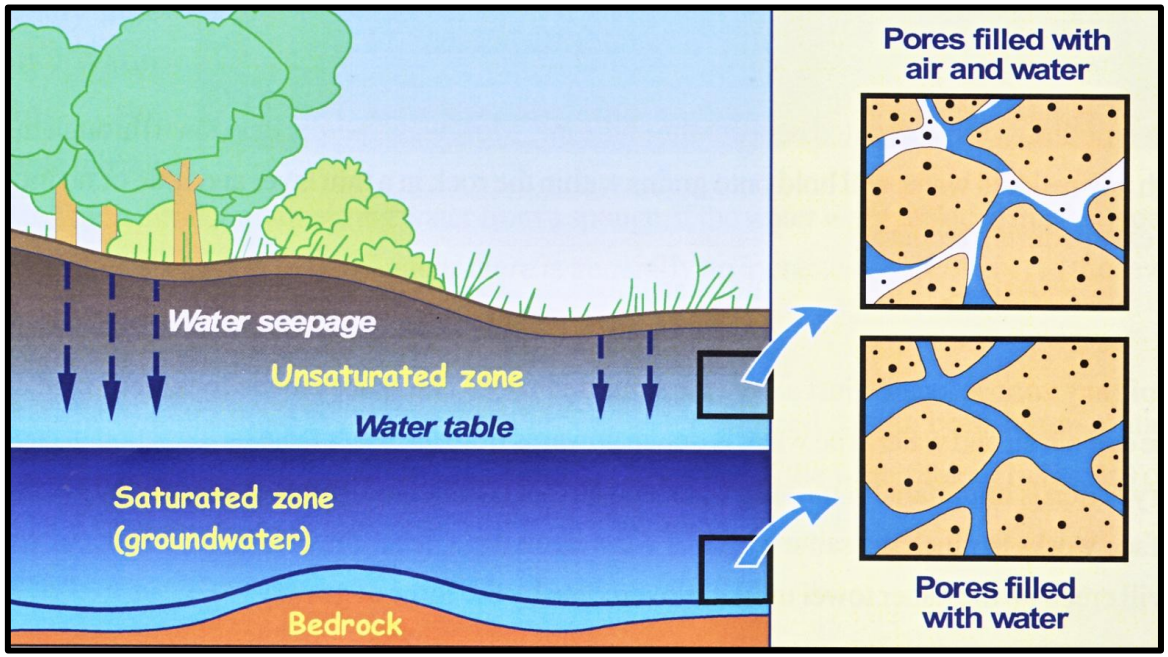
The Lower Tertiary Aquifer (LTA) in the Otway Ranges is commonly referred to in the Otway Water Books as the deep water aquifer and is made up of the Mepunga, the Dilwyn and the Pebble Point Aquifer Formations.

All of the overlaying material (MTD) above the LTA is both capable of having water pass through it and becoming saturated. The rate at which the water passes through and or leaks downwards from the aquitards (MTD) above into the depleted aquifers (LTA) below will vary.

To extract water from saturated aquitards is impractical when large volumes as in the Barwon Downs Borefield, are required. However, extracting water from the LTA is a different and economically viable proposition.

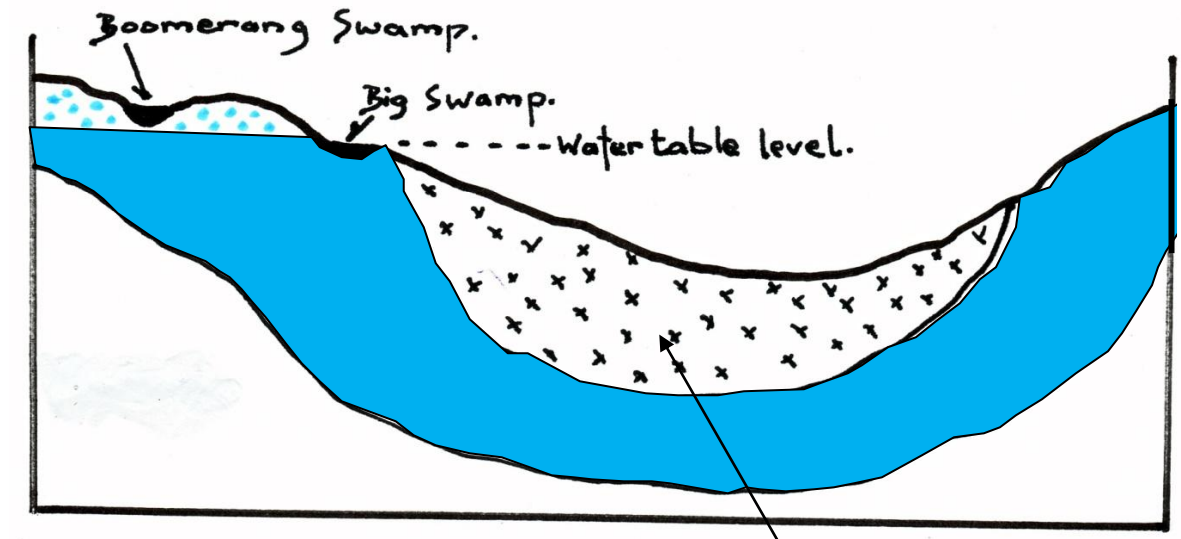
As part of the so called sustainability of the LTA water extraction process, the LTA will be replenished by water leaking from the structures above (MTD). Unfortunately extended periods of drought and extraction of huge amounts of groundwater extraction take their toll on the sustainability of surface waters, springs, wetlands and swamps above.

When it rains it has been calculated that between 5%,[37] 14%[27] and 28%[29] of this water readily soaks into the exposed unsaturated zone of the aquifer material on the Barongarook High (see the area marked in as blue on pages **35** and the blue dotted zones on page **49**)**.** This water under the force of gravity moves through this aquifer material towards the saturated water zones. As stated earlier only a geological material that can yield a useable quantity of groundwater from its saturated zone is called an aquifer.



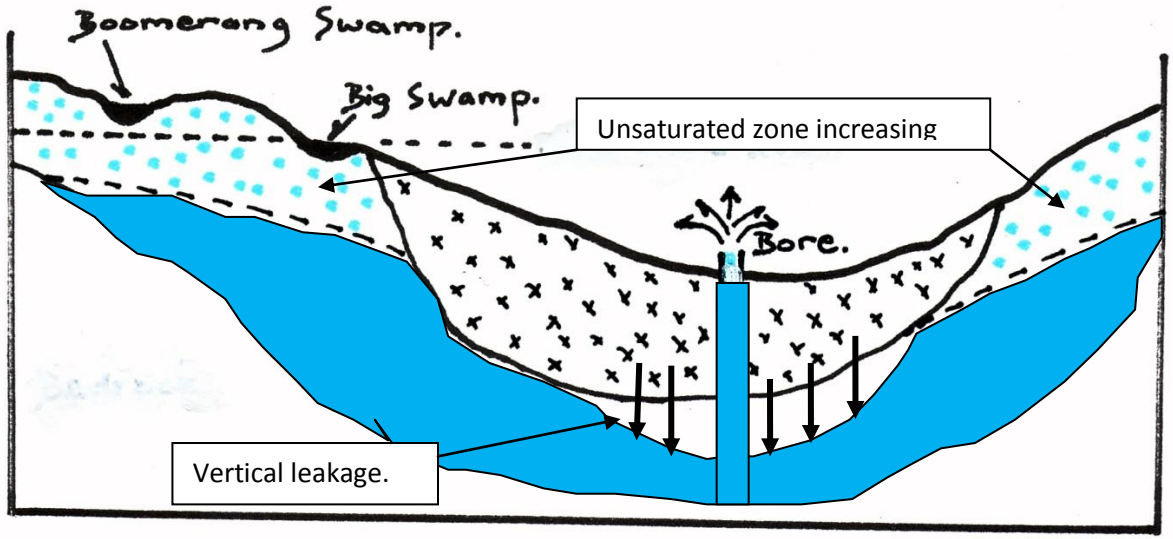
SOURCE: Australian Centre for Groundwater Studies.[7]

The unsaturated zone at the surface oscillates between being relatively dry during summer and relatively saturated during winter. However, this equilibrium can be upset with regular and sustained amounts of groundwater extraction from the deep water aquifer below. As an aquifer is depleted the phenomenon of vertical leakage downwards takes place. Over an extended period the saturated aquitard above the confined



Conceptual representations.

Confining beds containing saturated aquitards.



aquifer begins to dry out and causes a similar downwards leakage effect to take place all the way from the surface. Considering the amount of water extracted from the Barwon Downs Borefield and the extended period of 24 hours a day, 365 days a year pumping for some years, vertical leakage is inevitable. The Boomerang Swamp sits directly on top of the aquifer materials, is well within the zero point of drawdown influence and consequently would suffer from any vertical leakage taking place even if sitting on a perched swamp.

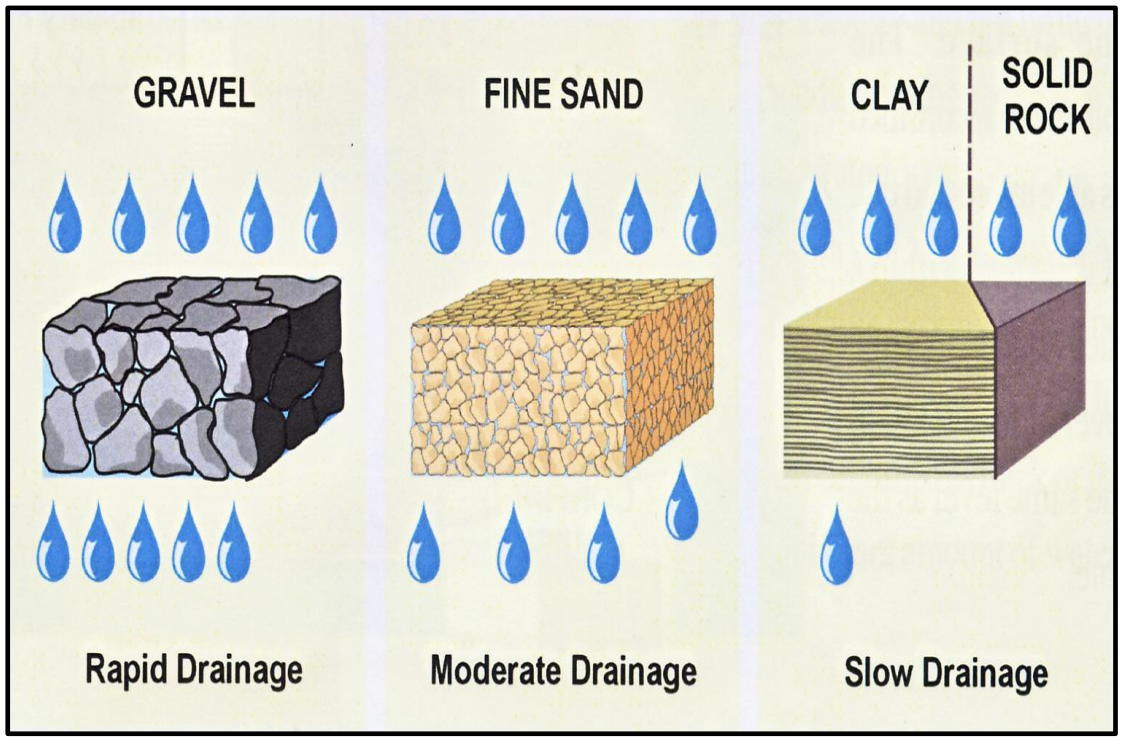
During rainfall events even when the sediments are drying out below, the surface layer supporting pastures and maintenance of vegetation, can give the false impression that things are "normal." However, a slow and insidious drying out of deeper layers may take years to impact and become apparent at the surface.

In the unsaturated zone the spaces within the soil sediments are filled with both air and water. In the saturated zone all of the spaces are completely filled with water.[7] The top of the saturated zone is called the water table level and the water in the saturated zone is regarded as groundwater. This water table level can change depending on a numbers of factors including evapotranspiration, rainfall, groundwater extraction and amount of discharge to springs, wetlands and streams.

As the water table level drops the unsaturated zone in the aquifer material in the Barongarook High increases creating a drying out effect in the area and extends the natural variations experienced over the summer period.

Any confining beds of less porous material tend to act as blankets holding the water into structures such as the deep water Dilwyn, Mepunga and Pebble Point aquifers or any higher perched aquifers. However, these confining beds also allow water to pass through them but at much slower rates. They can be saturated but do not provide a readily available yield of water for human use.
These confining beds can overlay, as in the LTA and or underlay an aquifer further up in the MTD. The confining overlaying structures of the area under discussion can be seen on page **47**. These confining beds or aquitards can be saturated but do not provide a useable yield of groundwater.

Not only does the unsaturated zone in the aquifer material increase as the water table drops, the unsaturated zones in the confining layers also increases though at a much slower rate. The longer and the lower the water table is dropped the larger and more pronounced becomes the unsaturated zone in all overlaying earth structures.



This extract from a manual prepared by the Centre for Groundwater Studies[7] presents the drainage rates of various material in an easily understood representation. All of these materials can be saturated.

The material structure that the Dilwyn, Mepunga, Pebble Point and overlaying confining beds consist of are gravel, cretaceous sediments, clays silt, sand and coal. All of these allow water to pass through them and all of them are capable of becoming saturated (see page **48**).

Source: Australian Centre for Groundwater Studies.

Leonard[28] discussed the distinct possibilities of vertical leakage taking place as far back as 1984. Also, a subsidiary objective of the 1987-91 test pump conducted at the Barwon Downs borefield was to examine groundwater movement between the deep water aquifer and the confining formations above (MTD). In 1995 when Witebsky et al.[37] summarised and made recommendations for Stage One groundwater extraction, it was found that there was insufficient monitoring done during the test pump to gain a clear understanding of the amount and influence of vertical leakage down into the deep water aquifer. Consequently the recommendation was made that in the advent of any revision of Barwon Water's licence, it should include a requirement to provide and monitor bores constructed into the overlaying clays to determine the amount of vertical leakage. To date there is no indication that this has ever been done, 28 years after it was first recommended. The 2008 Barwon Water Flora study report[29] discusses the possibility of vertical leakage and states that there is no evidence that this has occurred. However, only 3 of the 61 observation bores that Barwon Water monitor are located in these upper layers where vertical leakage would be taking place. If there is no data there will be no evidence. This same report states, "***In the MTD, water table depths are virtually unknown due to the paucity of observation bores.***" The MTD is the upper layer of material structures that sit above the aquifers that Barwon Water is extracting groundwater from (see page **47**).

The 2008 report also states, "***Due to the thickness and low hydraulic conductivity of the overlying aquitard, it is unlikely that there has been any significant decline in the water table in the aquitard but it could occur over longer time frames.***" Considering the fact that the collection of data relevant to vertical leakage has been recommended on several occasions going back as far as 1986[14] and stated as a distinct possibility going back to 1984, [28] it seems incredible that nothing has been done other than to make statements such as these. And, what is regarded as a "*longer time frame"?* How can such a statement be made when there is "virtually" no data to support it, one way or anaother?

When SKM was preparing various scenarios on pumping extractions in the 2000s renewal of the groundwater extraction licence process, it was stated that part of the sustainability of the deep water aquifer was water moving from the structural layers of the MTD down into the depleted aquifer below. This being vertical leakage. Little consideration was given to the impacts of this process on the surface and structural layers from which this water would leak.

Barwon Water was asked in February 2010, "*Is it also possible to have a copy of any work done or commissioned by Barwon Water, on vertical leakage between aquifers in the Barwon Downs borefield investigations?*"
Dated 16 February 2010, Barwon Water Ref: 55/100/0001C, the reply was, "*In relation to your request regarding any investigations Barwon Water has conducted with respect to vertical leakage between aquifers in the Barwon Downs borefield, there have been no such studies since*

the pre-licence renewal investigations in 2002-03." Other than SKM stating that vertical leakage from above into the aquifers that Barwon Water pumped from and that this was one way the deep water aquifers would be sustainable, the only studies able to be accessed, if they could be called studies, can be found in Appendix Three, pages 119-131 & Appendix Four, pages 132-134. In effect there have been no studies conducted on vertical leakage within the Barwon Downs Borefield sphere of influence and this is in spite of the fact that recommendations to do this go back several decades.

The final words on vertical leakage can probably best be summed up in the Corangamite Catchment Management Authority's Regional Catchment Draft Strategy for 2012-2018[9] when discussing the lower aquifers in the region that are high yielding and used for urban water supply and it states... ***"The lower aquifers are mainly recharged from leakage from the overlaying aquifers."*** Vertical leakage is a reality and water moving from the surface down into the depleted lower aquifers has to be taking place below the Boomerang Swamp. Until studies are implemented the amount of impact will never be known.

Is the Boomerang Swamp influenced by Groundwater Extraction at the Barwon Downs Borefield?

Late in 2008, early 2009 Barwon Water commissioned Sinclair Knight Merz (SKM) to conduct a flora study[29] as part of the Barwon Downs Borefield licence requirements. When Southern Rural Water issued the licence Number 893889 in 2004 one of the conditions was that a report on hydrological sensitive vegetation within the sphere of influence from the borefield had to be prepared within 5 years. Originally Sites 78 and 79 were to be included in this work and reasons for their omission have already been dealt with in some detail.

SKM engaged Ecology Australia Pty Ltd to conduct the flora section of this first five year report. After completion it was reported in the Colac Herald [8] and through a media release[3] that the findings were inconclusive. Otway Water Book 9[25] deals solely with the scrutiny of this report and its criticism is scathing to say the least. Book 9 highlights the deplorable manner in which the regulating body, Southern Rural Water, granted a licence with such a poorly constructed, researched and limiting set of conditions and restrictive brief.

Despite this there are several extracts that can be taken from this 2008 SKM report that assists with the endeavours to understand and determine the degree of connectedness and influence emanating from groundwater extraction at the Barwon Downs Borefield on the Boomerang Swamp area.

3.6. Perched Water Table

A perched water table by definition is hydraulically isolated (ie independent) from regional groundwater systems and as such, are not impacted by pumping stresses applied to a regional water table system (such as the LTA). Perched water tables are often found at locations where very large changes in soil permeability occur near the ground surface, such as layers of clay in a sandy soil. The aquifer pumped by the Barwon Downs borefield is known to be heterogeneous in nature (ie comprise layers of high and low permeability sediments (Dudding, 1991) and, as such, has the potential to form perched water tables. It is likely that perched water table are present in the study area, but their location cannot be reliably predicted with the hydrogeological data currently available.

The water table elevation data obtained from observation bores on the Barongarook High is not suitable for predicting the location of perched water tables because these bores monitor the regional groundwater system. This is supported by the lack of regions of high or low groundwater elevation that don't fit with the regional flow pattern as shown on the groundwater elevation maps for 1986

SINCLAIR KNIGHT MERZ

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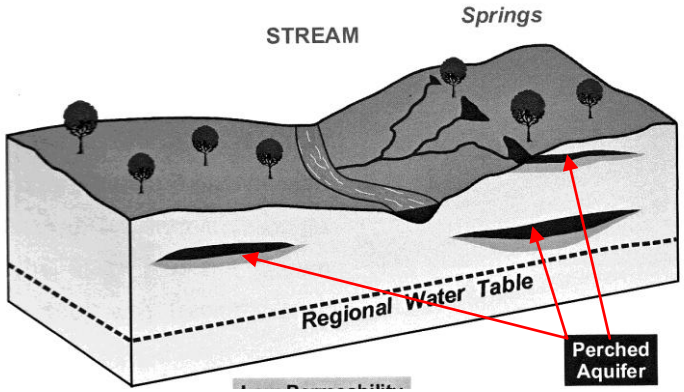
PAGE 28

SOURCE: SKM Barwon Downs Flora Study 2008[29]



SOURCE: Australian Centre for Groundwater Studies.

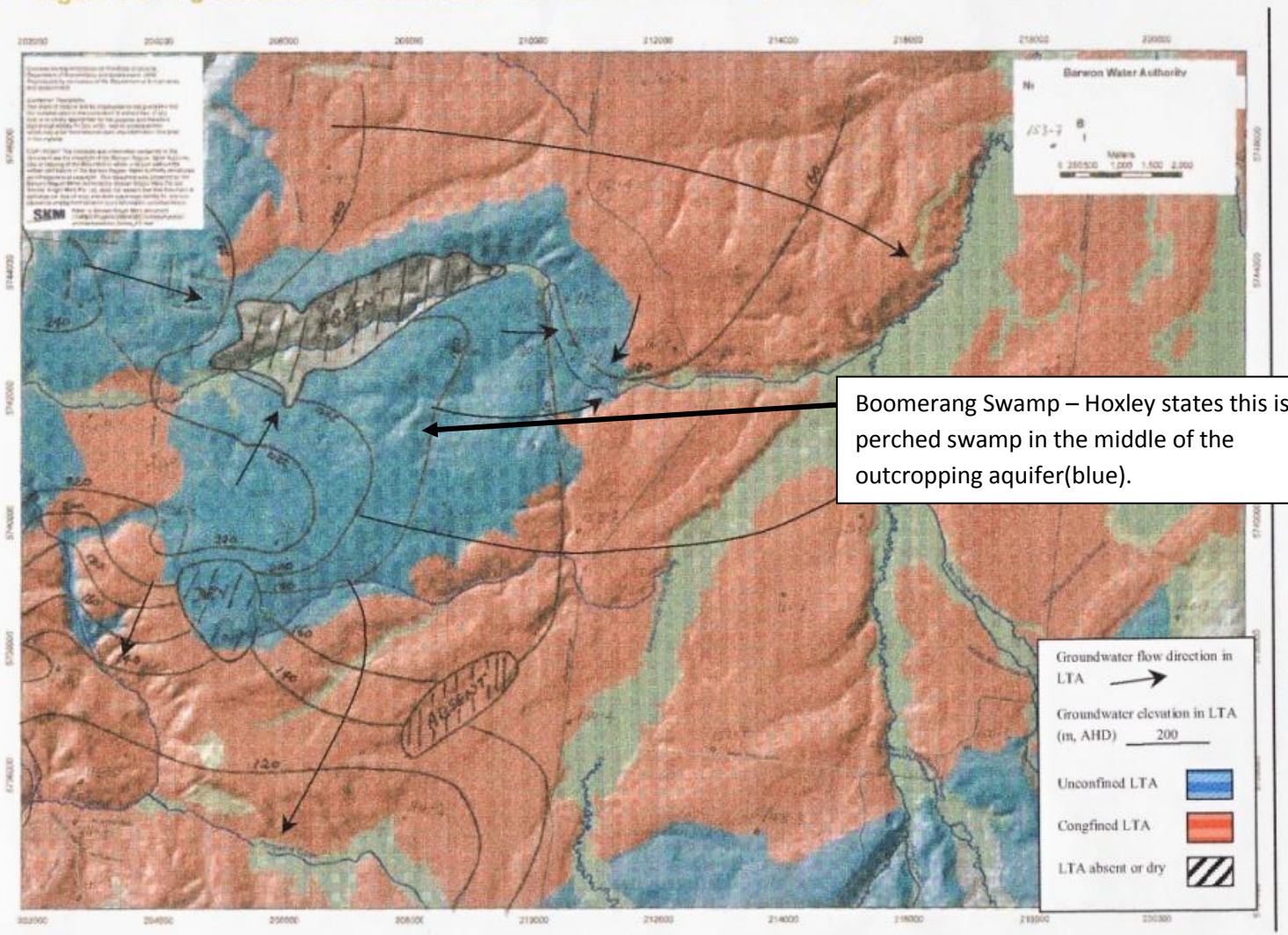
SKM

and 2008 (Figure 6 and Figure 12). Any perched water table present would have an elevation above that shown in Figure 6 and Figure 12.

3.7. Water Table Depth

Figure 6 and Figure 12 can be found reproduced on the next two pages.

Figure 6 LTA groundwater elevation and flow direction in 1986 (prior to groundwater pumping)



Boomerang Swamp – Hoxley states this is a perched swamp in the middle of the outcropping aquifer(blue).

SINCLAIR KNIGHT MERZ

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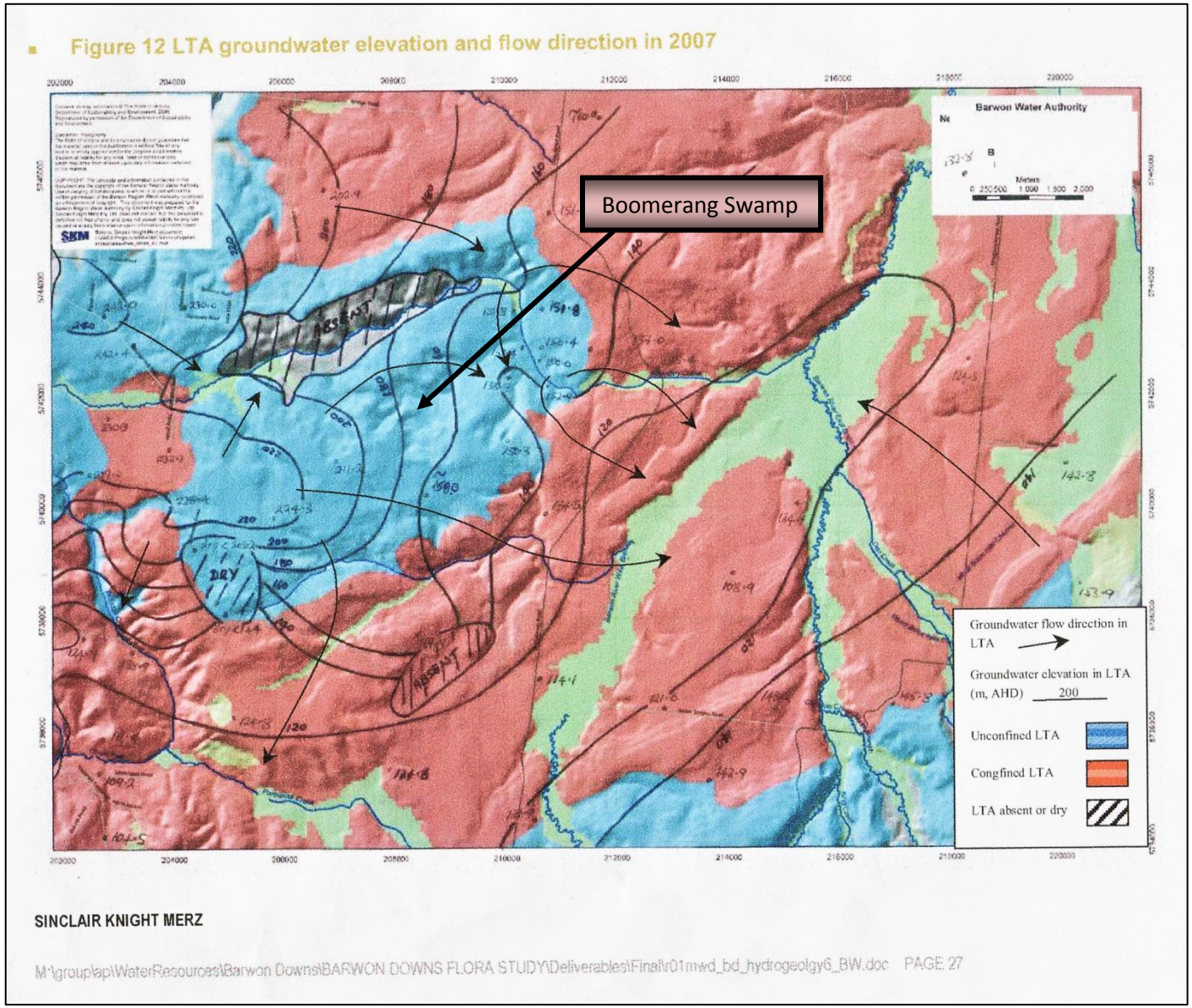

The guess work of 2008 stating "***It is likely that***..."[29] the Boomerang Swamp sits on a perched water table is problematic and has never been established. For Hoxley and the Technical Group reviewing the 1995 groundwater extraction licence in 2003 to determine the fate of a swamp of State botanical significance on a "*similar likelihood*" is neither scientifically acceptable nor is it acceptable to fail to follow up with data collection in an attempt to verify such guess work and generalisation. Any follow up work as recommended in the draft licence conditions has never been instigated because the Technical Review Group scrapped any such notion.

As stated above the necessary data has never been available to predict the location of any perched aquifers on the Barongarook High and supports the belief that when Hoxley stated that Sites 78 and 79 were part of a perched aquifer, he

was purely making an educated guess at best.
The 2008 Flora report and research shows that the Boomerang Swamp lies within the exposed LTA, is well inside the area of drawdown influence and has not been identified as a perched swamp.

The following statements made by Hoxley back in 2003 could not be justified.

- ***Shallow (local systems) largely not affected by groundwater pumping.***
- ***Flora sites 46, 78, & 79 are not connected to regional water table – they are perched above the highest level of the water table. e.g site 46 is 30m above regional water table and therefore the vegetation is not affected by the pumping.***
- ***Water levels at Flora sites 46, 78 & 79 should recover faster than Regional System.***

In an attempt to obtain the data, studies and material on which Hoxley based these statements this email was sent to Ian Davis of Barwon Water.

From: Mal Gardiner <otwaywater@yahoo.com.au>
To: Ian Davis <Ian.Davis@barwonwater.vic.gov.au>
Sent: Sunday, 22 April 2012 12:32 PM
Subject: Querry re: a 2003 report.

Dear Ian,
Back on 9 January 2003 you were present on a Technical Group re: the Barwon Downs Groundwater Panel looking at the renewal of the licence. Greg Hoxley presented a report on Flora Sites 46, 78 and 79; sites designated these number by Geoff Carr of Ecology Australia.

In a lead up to the final licence it was stated under section 7.1 A. in a draft that Barwon Water must demonstrate that these sites are not dependent on groundwater discharge from the regional water table.
Greg Hoxley's work provided this assurance.

My query being could you provide me with a copy of his determination and the data/investigations used to support this determination.

Could you confirm that you have received this email.

Thanks very much,
Malcolm.

Malcolm Gardiner
1805 Colac Lavers Hill Road
Kawarren
Vic 3249
ph (03) 52 358 325
www.otwaywater.com.au

On 16/05/2012, at 9:46, **Ian Davis** <Ian.Davis@barwonwater.vic.gov.au> **wrote**:

Hello Malcolm,

I have looked into our records and advise that in January 2003, Greg Hoxley verbally reported to the Technical Group in regards to Sites 46, 78 and 79 the following;

- These were not connected to the regional water table – they are perched above the highest level of the water table eg Site 46 is 30m above the regional table.

- Water levels at these sites should recover faster than the regional system.

I have not been able to locate any other information on this matter and assume the Technical Group accepted his expert knowledge on this matter.

I understand that you have previously been advised to refer any enquiries in relation to the Barwon Downs Borefield to our Tony Overman and I would appreciate if you could follow this protocol.

I have forwarded your email regarding Paul Northey to Tony for his response.

Regards

Ian Davis

This is the first I heard of this protocol arrangement

After some prompting this reply arrived.

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If it is the case that the Technical Group blindly accepted Hoxley's advice because he was an expert without asking him to provide any documentation then this is quite alarming. In light of the statements made in the SKM 2008 Flora report that there was insufficient data to establish whether there were any perched swamps in the area and the fact that Hoxley was employed by the very same company that prepared the 2008 report, SKM; adds a further piece of intrigue to the conundrum.

On the very day that the above email was received from Ian, I came across reference to the following two reports was found.

- Sinclair Knight Merz (January 2003) Boundary Creek Vegetation Surveys – Relationship to Groundwater Levels Report to Barwon Region Water Authority, and
- Sinclair Knight Merz (June 2003) Gerangamete Groundwater Flora Site Levels, Report to Barwon Regional Water Authority.

A Freedom Of Information request was sent to Barwon Water asking for copies and the reply arrived in due course. The January report can be found in Appendix Three, pages 119-131 and the June report is in Appendix Four. For some reason not explained, the figure and file that were attached to the June report were not included in the FOI reply.

These two reports threw up some very interesting revelations.

Regarding Site 46.

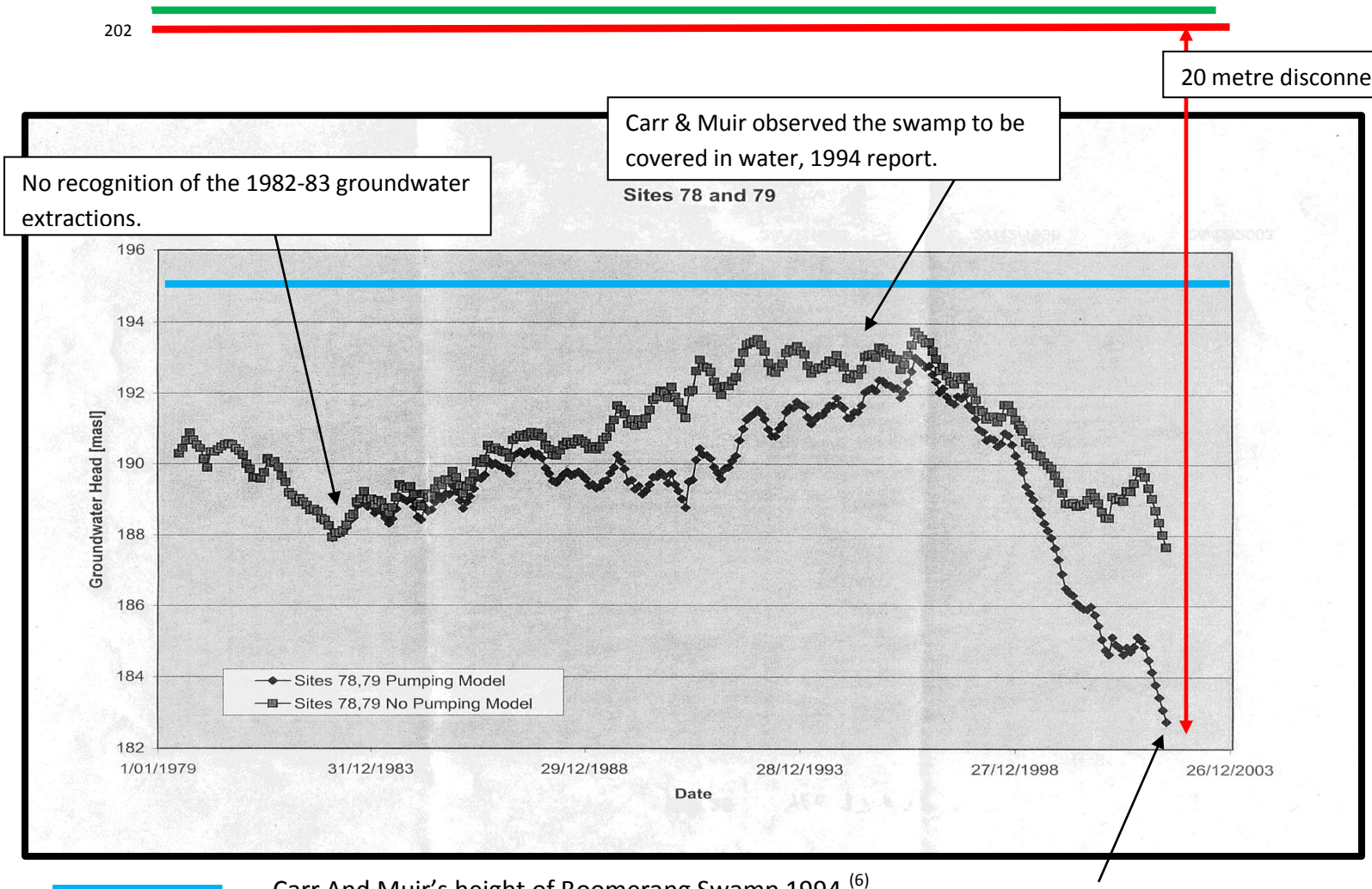
- Not that Site 46 is part of this discussion it is significant that this site has been calculated as being 20 metres (see pages 60 and 132) above the water table in one document and 30 metres (See page 56) in another.

Regarding the graph of the modelled water levels for Sites 78 & 79 from the January Report 2003 (see the page 60).

- The figures represented in this graph have been calculated using modelling. One graph represents what the model for a non pumping scenario would be and the other graph is the calculations for the effects from pumping.
- These figures are calculated guess work and are not from actual on site data or observations.
- The assumptions/guess work that the modelling was based on has not been stated.
- Drawn across this graph are different heights for the Boomerang Swamp as determined by three different calculations. The red line shows the height to be approximately 202 metres AHD, taken from the January 2003 report. The blue line is the height stated by Carr and Muir in their 1994 report.[6] The green line, the most recently done, shows Harry Reid's calculated height.
- The pumping and non pumping modelled graphs are shown as identical during the 1982-83 drought pumping period. This seems improbable. During the 1982-83 drought the extensive Barwon Downs Borefield groundwater extractions were a critical factor in Geelong maintaining a water supply to its customers and appears to have been overlooked in the modelling calculations. The non pumping scenario should have tracked higher than the pumping calculations.
- How these modelling calculations were done is a complete mystery. Barwon Water cannot find records of groundwater extractions pre 1988[16] and this may explain why the non pumping and pumping graphs are the same in the 1982-83 period.

- When flora and fauna studies were conducted in the 1990s it was stated that there had been no groundwater extractions prior to these studies being conducted.[18,21,25] More nonsense. It is easily understood how modelling scenarios give a false and skewed picture when all relevant data is not fed into the model. If modelling assumptions and data that is fed into the computer are wrong the whole modelling scenario becomes skewed.
- Using the lowest point of the water table in 2002 after extensive pumping, over 100 000 ML, and using this level to justify the statement that Boomerang Swamp is 20 metres higher than the water table and is not connected to the deep water aquifer, is a gross misrepresentation. The assumed water table level without any pumping what so ever would be the most indicative of any connectedness but from the paucity of data available for this level is not reliable but is at least 13m higher than the one used.
- At the very least the non pumping water table model level in 2002 should have been the level used. However, considering the extensive pumping that had taken place up to this period it is extremely doubtful that any credence could be placed on this level as an accurate reference point.

It would appear that a poorly researched effort was made to clarify whether the Boomerang Swamp was directly or indirectly connected to the outcropping deep water aquifer that Barwon Water was extracting groundwater from. The manner in which it has been justified, that there is no connection between the deep water aquifer and the Boomerang Swamp, and that the swamp sits on a perched aquifer, is extremely suspect and requires some considerable explanation and clarification. Perhaps it is time to implement a vertical leakage study, a recommendation that has been made several times over three decades.



The red, blue and green lines show the AHD height of the Boomerang Swamp as determined by Carr & Muir, SKM and Reed.

The most up to date and accurate AHD level of Boomerang Swamp would have to be the calculation done by Reed.

Source of the graph: January 2003 SKM report[31]

Carr And Muir's height of Boomerang Swamp 1994.[6]

SKM's height of Boomerang Swamp 2003, see page 132.

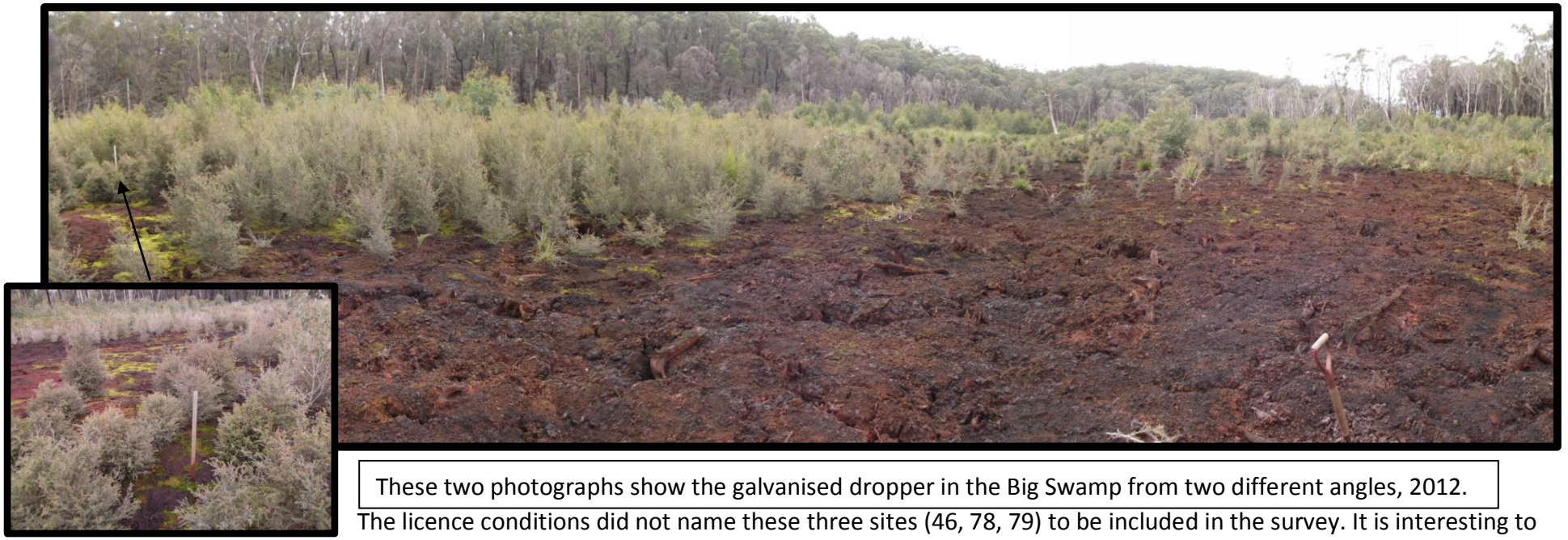
Reeds's height of Boomerang Swamp 2012 almost identical to SKM's

This is an extract from the Groundwater Renewal Panel meeting 9 January 2003...

Outcomes and future actions

- ***Flora sites 46, 78 & 79 are not connected to Regional Groundwater Table therefore only require shallow (2-3m) hand augured monitoring bores at two sites. Also gauge to measure surface water levels.*** Not done.
- ***Monthly monitoring of Regional water table to include monitoring of shallow watertable to demonstrate non-conductivity.***
- ***For sites 46, 78 & 79 there needs to be agreement who monitors flora when Regional groundwater system has returned to normal given that the change in vegetation is not related to Barwon Water activities.*** Not done.
- ***Flora monitoring sites need to be clearly marked.*** Done in 2008.

The monitoring bores that were recommended in 2003 have not been drilled AND there has been no research undertaken to determine whether the Boomerang Swamp sits on a perched aquifer or not. It would appear that no one has taken ownership or determined whose responsibility it is to monitor the swamps referred to above. When conducting the 2008 flora survey Carr and his team took the initiative and clearly marked Sites 78 and 79 in the Boomerang Swamp and the Big Swamp (see page 5) with star pickets. These sites were not included in the brief of the 2008 study.



These two photographs show the galvanised dropper in the Big Swamp from two different angles, 2012.

The licence conditions did not name these three sites (46, 78, 79) to be included in the survey. It is interesting to

note however that before SKM were commissioned to carry out the 2008 Chris Hughes of Southern Rural Water stated emphatically that the Big Swamp would be included in the survey.[17] Considering that Barwon Water required the Department of Sustainability & Environment and Southern Rural Waters' approval to proceed (see page 41, Point 7.1 B) it is very confusing why the Big Swamp was not included. However, this is another story but does highlight how easily important issues can be overlooked or swept under the carpet. (This story is told on pages 86-100)

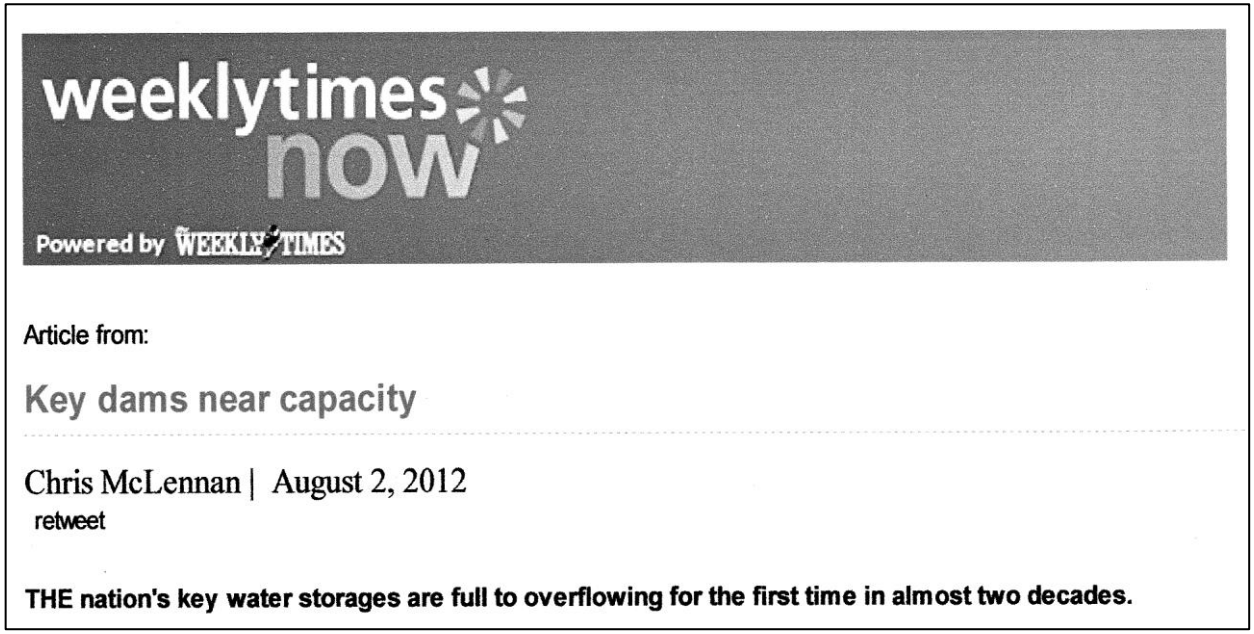
The Recovery of the Boomerang Swamp.

Based on Hoxley's assumptions that the Boomerang Swamp was a perched swamp and not connected to groundwater extraction at Barwon Downs, he stated that as a result the Boomerang Swamp water levels should recover faster than the Regional System. Unfortunately, this has not been the case and the Boomerang Swamp has remained dry after the late 1990s/early 2000s drought until October 2012 after the third wet winter following this drought.

In August 2012 Melbourne water storages reached their highest levels in 15 years.

The Weekly Times also reported that the West Barwon, West Gellibrand and Olangolah Reservoirs were 100% full. Colac regional storages were 95.7% full for the same period last year.

All above ground dams, reservoirs, swamps and the like were close to full capacity, all except the Boomerang Swamp and the Big Swamp both within the Barwon Downs Borefield area of influence.



weeklytimes now

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Article from:

Key dams near capacity

Chris McLennan | August 2, 2012

retweet

THE nation's key water storages are full to overflowing for the first time in almost two decades.

Even after the Boomerang Swamp district experienced snow, heavy rain, strong winds and freezing temperatures during June, July and August 2012 the Boomerang Swamp was still dry.

In effect the exact opposite to Hoxley's prediction took place. It wasn't until the last week in September that the Boomerang Swamp started pooling water.

A wet and windy winter

by Kate Wilson

Colac Herald 31 Aug 2012

Colac and district has experienced snow, heavy rain, strong winds and freezing temperatures in the past three months.

The West Barwon reservoir overflowed for the first time in ten years in June.

Nearly 50 millimetres of rain fell at Forrest on August 18 and 19, causing water to spill over the reservoir dam wall again, at a rate of 150 million litres an hour.

The temperature gauge at Mount Gellibrand, north-east of Colac recorded its lowest minimum temperature for the year of 1.9 degrees Celsius on July 8.

The maximum for that day was 13 degrees.

Snow fell in the Otways at Beech Forest, Ferguson and at Wyelangta last week.

Wind gusted at more than 100 kilometres an hour in August, toppling trees onto Colac district roads.

Colac's State Emergency Service responded to seven calls for assistance on August 5 and 6.

Close to 200 millimetres of rain fell in Colac over the three months of winter.

Meanwhile, the rain totals across Colac for August were both above and below average.

The rain gauge at Colac Otway Shire Council's offices recorded 80.4 millimetres for August, which was below the 20-year average of 100.21 millimetres.

The Bureau of Meteorology's observation station at Mount Gellibrand, north-east of Colac, received 64 millimetres, which is above the 12-year average of 61.1 millimetres.

Colac rain watcher Alf Wilhelms recorded 94 millimetres for the month at his Hearn Street home.

"Which is very close to the long-term average," Mr Wilhelms said.

"People have thought it was wetter than it was, and the main reason for that is because there was so much misty weather," he said.

"That meant less sunshine, and people noticed it."

Rain watcher Evan Robb recorded rain on 20 days of the month at his Colac home.

He said he recorded 82.25 millimetres, which is above last year's total for August of 51.25 millimetres.

Otways weather enthusiast Rupert Hewison recorded 249 millimetres at his Beech Forest home, above the long-term average of 210 millimetres.

"Rain fell on 26 of the 31 days and the heaviest daily fall was 51 millimetres in the 24 hours to 9am on Saturday, August 18," Mr Hewison said.

Barwon Water

Learning Centre » Water storage levels » All water storages

All water storages

Location	Total capacity (ML)	Present volume (ML)	Same time last year (ML)	Weekly variation (ML)	% full
West Barwon Reservoir	21,504	21,504	18,219	+0	100.0
Wurdee Boluc Reservoir	38,056	36,170	34,742	+1,052	95.0
Korweinguboora Reservoir	2,091	2,091	2,091	+0	100.0
Bostock Reservoir	7,455	7,455	7,455	+0	100.0
Stony Creek reservoirs	9,494	6,018	8,908	+306	63.4
Lal Lal Reservoir (Barwon Water's share)	16,793	16,793	16,793	+0	100.0
Geelong total	**95,393**	**90,031**	**88,208**	**+1,358**	**94.4**
West Gellibrand Reservoir	1,856	1,856	1,856	+0	100.0
Olangolah Reservoir	152	152	152	+0	100.0
No. 4 Basin Colac	196	171	169	+2	87.2
No. 5 Basin Colac	472	388	432	+15	82.2
Colac Total	**2,676**	**2,567**	**2,609**	**+17**	**95.9**
Marengo Basin (Apollo Bay)	125	118	123	+3	94.4
Allen Reservoir (Lorne)	222	222	222	+0	100.0
Painkalac Reservoir (Aireys Inlet)	532	532	532	+0	100.0

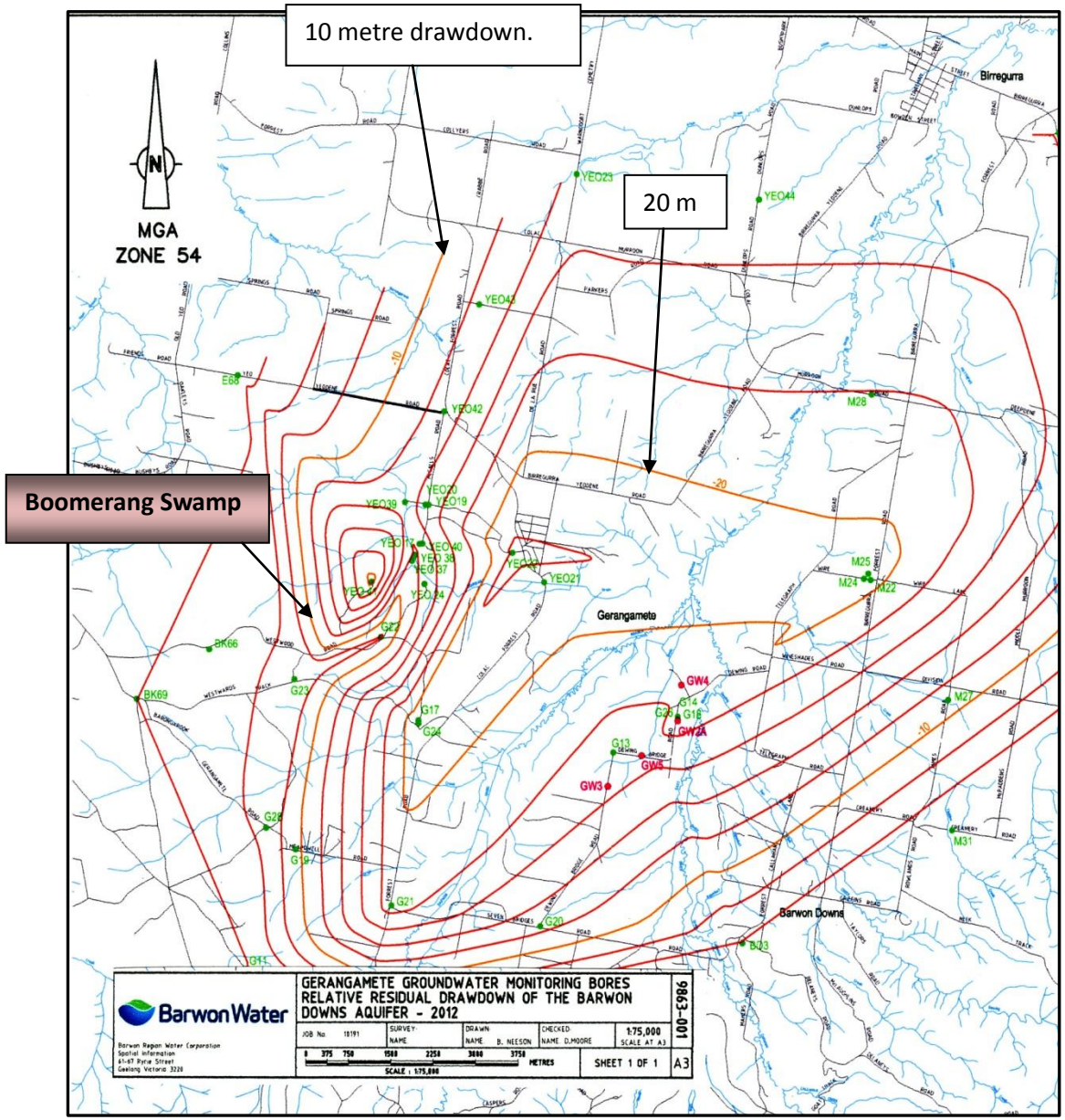
Notes

- Volumes are expressed in megalitres (ML). 1 megalitre is 1 million litres.
- Figures are updated daily (subject to availability of data).
- Data is current as at midnight on the previous day.
- All figures are subject to validation.

Page Last Updated Friday 24 August 2012

Photographs of Boomerang Swamp taken just after a very wet period when surface water began to accumulate. (early October 2012)

The month previous to taking these photographs had been extremely wet . Considering that surface dams and reservoirs of the region as mentioned above, the fact that it took so long for the Boomerang Swamp to once again hold water places additional doubt on the validity and wisdom of the recommendations made to the Barwon Downs Licence Review Panels in 2003 regarding this swamp. This swamp took three wet winters to begin to pool surface water. The upper reaches of the Big Swamp still remains dry.



Bearing in mind that the last three winters were very wet and that Barwon Water stopped pumping over two years ago (August 2010), it is worth noting that the residual drawdown under Boomerang Swamp was still in the order of 10 metres at the end of June 2012. Even long after the extraction of water ceased the aquifer was still very much in its recovery stage. As Evans of SKM stated[12,13] aquifer recovery may take decades and in some cases impacts have been known to first become apparent decades after pumping ceases.

In Southern Rural Water's November 2012 Local Water Report these statements were made:

- ***"The entire Otway Coast basin received good autumn rains and heavy to very heavy rainfall in winter..."***
- ***"...and setup good flows for summer..."***
- ***"...with all storages filling and spilling."***

Water extraction from the Gellibrand and Carlisle Rivers had no rostered restrictions implemented last season while Lake Purrumbete irrigator licence holders took water throughout the last season. Lake Purrumbete will be full for this season.

This report goes on to say that the local groundwater in the Gellibrand Groundwater Management Area has declined between 1 to 4 metres since 1997. Newlingrook levels are close to stable with a slow declines of up to 3.75 metres in the same period. Jan Juc levels are stable or slightly declining. However, no mention was made of the levels in the Gerangamete Groundwater Management Area (GGMA) that encompasses the Barwon Downs Borefield.

It is a mystery why this report didn't give an update on groundwater levels in the Gerangamete GMA. Some bore water levels have been recorded with drops of up to 60 metres with other levels having dropped throughout the Gerangamete GMA far in excess of neighbouring GMAs groundwater levels.

Concerns Over Potential Inland Freshwater Acid Sulfate Soil.

Knowing that there was a source of acid water being generated in this area of the Barongarook High region and from experience knowing that little assistance would be forthcoming from the statutory authorities,[15] the decision was made by the LAWROC Landcare Group to conduct basic Acid Sulfate Soil tests of soil in the Boomerang Swamp. Initial testing of the soil using hydrogen peroxide as an oxidising agent indicated that there was a high probability that there was Potential Inland Freshwater Acid Sulfate Soils present.

This litmus test indicated a pH level, after oxidation, between 2 and 3. (2011)

Using a Dick Smith pH meter indicated a level below 2. (2011)

Throughout the swamp there were skeletons of yabbies lying amongst the dead vegetation. This was another indication that there was a problem.

These initial observations and hydrogen peroxide testing prompted the gathering and sending off to the Southern Cross University Environmental Analysis Laboratory, several soil samples for testing.

Site 79, 8 Dec. 2013. The high water mark indicated on this dropper was reached in early October 2012 (see pages 77and 83and Appendix 5.)

RESULTS OF ACID SULFATE SOIL ANALYSIS

10 samples supplied by Land and Water Resource Otway Ranges on the 7th June, 2012 - Lab. Job No. C0380
Analysis requested by Malcolm Gardiner. **Your Project: Peat Swamp**
(1805 Colac - Lavers Hill Road, KAWARREN VIC 3249)

Required if pH_{KCL} <4.5

Sample Site	EAL lab code	TEXTURE (note 6)	MOISTURE CONTENT (% moisture of total wet weight)	MOISTURE CONTENT (g moisture / g of oven dry soil)	TITRATABLE ACTUAL ACIDITY (TAA) (To pH 6.5) pH_{KCl}	TITRATABLE ACTUAL ACIDITY (TAA) (To pH 6.5) (mole H^+/tonne)	Extractable sulfate sulfur $\%S_{kcl}$	Extractable sulfate sulfur (equivalent mole H+/tonne)	REDUCED INORGANIC SULFUR (% chromium reducible S) (%Scr)	REDUCED INORGANIC SULFUR (% chromium reducible S) (mole H^+/tonne)	RETAINED ACIDITY (HCL extract) (as $\%S_{HCL}$ - $\%S_{kcl}$) ($\%S_{NAS}$)	S_{NAS} (mole H^+/tonne)	NET ACIDITY Chromium Suite mole H^+/tonne (based on %Scrs)	LIME CALCULATION Chromium Suite kg $CaCO_3$/tonne DW (includes 1.5 safety Factor when liming rate is $^+$ve)
Method Info.					*(ACTUAL ACIDITY)*				*(POTENTIAL ACIDITY)*		*(RETAINED ACIDITY)*		*note 5*	*note 4 and 6*
BOS 1	*C0380/1*	Fine	55.3	1.2	3.97	317	0.011	7	0.01	6	0.01	7	330	24.8
BOS 2	*C0380/2*	Fine	52.7	1.1	4.11	158	0.003	2	0.01	6	0.01	3	166	12.5
BOS 3	*C0380/3*	Fine	49.8	1.0	4.08	166	0.002	1	0.02	12	0.01	5	183	13.7
BOS 4	*C0380/4*	Fine	60.8	1.6	4.14	231	0.004	2	0.03	19	0.01	4	253	19.0
BOS 5	*C0380/5*	Fine	68.4	2.2	4.20	290	0.006	3	0.02	12	0.01	7	309	23.2
Circle 1	*C0380/6*	Fine	56.8	1.3	3.90	218	0.265	165	10.61	6617	0.02	10	6846	513.4
Circle 2	*C0380/7*	Fine	44.1	0.8	2.50	858	0.924	576	0.04	25	1.22	569	1452	108.9
PP1	*C0380/8*	Fine	50.8	1.0	2.51	612	1.234	770	0.12	75	0.00	0	687	51.5
PP2	*C0380/9*	Fine	59.2	1.4	2.83	924	0.574	358	0.07	44	2.01	940	1908	143.1
Bracken	*C0380/10*	Fine	34.2	0.5	2.55	517	0.451	281	0.06	37	1.93	904	1459	109.4

NOTE:
1 - All analysis is Dry Weight (DW) - samples dried and ground immediately upon arrival (unless supplied dried and ground)
2 - Samples analysed by SPOCAS method 23 (ie Suspension Peroxide Oxidation Combined Acidity & sulfate) and 'Chromium Reducible Sulfur' technique (Scr - Method 22B)
3 - Methods from Ahern, CR, McElnea AE , Sullivan LA (2004). *Acid Sulfate Soils Laboratory Methods Guidelines.* QLD DNRME.
4 - Bulk Density is required for liming rate calculations per soil volume. Lab. Bulk Density is no longer applicable - field bulk density rings can be used and dried/ weighed in the laboratory.
5 - **ABA Equation: Net Acidity = Potential Sulfidic Acidity (ie. Scrs or Sox) + Actual Acidity + Retained Acidity - measured ANC/FF (with FF currently defaulted to 1.5)**
6 - The neutralising requirement, lime calculation, includes a 1.5 safety margin for acid neutralisation (an increased safety factor may be required in some cases)
7 - For Texture: coarse = sands to loamy sands; medium = sandy loams to light clays; fine = medium to heavy clays and silty clays
8 - .. denotes not requested or required. '0' is used for ANC and Snag calcs if TAA pH <6.5 or >4.5
9 - SCREENING, CRS, TAA and ANC are NATA accredited but other SPOCAS segments are currently not NATA accredited
10- Results at or below detection limits are replaced with '0' for calculation purposes.
11 - **Projects that disturb >1000 tonnes of soil, the ≥0.03% S classification guideline would apply (refer to acid sulfate management guidelines).**
12 - Results refer to samples as received at the laboratory. This report is not to be reproduced except in full.

NATA
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(Classification of potential acid sulfate material if: coarse Scr≥0.03%S or 19mole H^+/t; medium Scr≥0.06%S or 37mole H^+/t; fine Scr≥0.1%S or 62mole H^+/t) - as per QUASSIT Guidelines

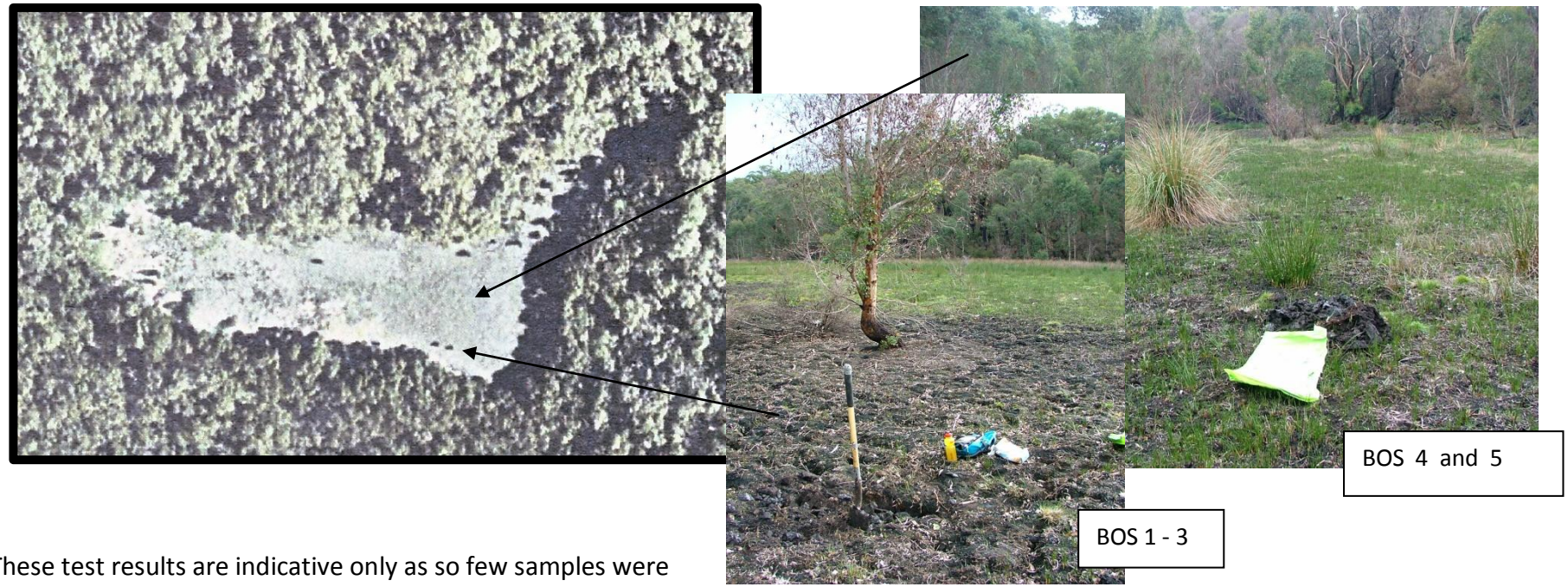
checked: .....
Graham Lancaster
Laboratory Manager

Environmental Analysis Laboratory, Southern Cross University,
Tel. 02 6620 3678, website: scu.edu.au/eal

The Acid Sulfate Soil Analysis test result sheet above includes five samples collected in the Boomerang Swamp. These are labelled BOS 1 to 5.

BOS 1-3 are from one site. BOS 1 was taken at 900 mm depth, BOS 2 at 450 mm and BOS 3 at the surface.

BOS 4 and 5 were taken from another site with BOS 4 at 900 mm and BOS 5 at 450 mm.



These test results are indicative only as so few samples were taken. However, there is no doubt that there is no neutralising capacity within this soil structure; that there is considerable acidity and that there is every indication that this is an Actual Acid Sulfate Soil site. Clearly there is enough data suggesting that a potential problem does exist and that further diagnostic and detailed investigation in regard to Acid Sulfate Soils of this particular swamp is warranted.

A water sample (W416) was collected from the Boomerang Swamp and sent off for analysis using an Induction Coupled Plasma Optical Emission Spectrometer.

WATER ANALYSIS REPORT

Name Lawrock Landcare Group
Malcolm Gardiner
03 5235 8325
otwaywater@yahoo.com.au

Test No.	Area	Post code	Code	Description
2 : 27	0	0	W413	BSW 1, 25/06/12
0	0	0	W414	Chariexs Creek 03/07/12, VW
0	0	0	W415	JCW 60-70 04/07/12
0	0	0	W416	BOSW 1, 04/07/12

Sample Date Date Test 1/08/12

Macro & Trace Elements - ppm (mg/kg; mg/l)

Guidelines	pH	B	Ca	Cr	Co	Cu	Ge	I	Fe	F	Li	Mg	Mn	Mo	P	K	Rb	Se	Si	Na	S	Sr	V	Zn
*WHO**	*6.5-8.5*	*3.0*	*20.0*	*0.05*	*na*	*1.50*	*na*	*0.10*	*0.30*	*4*	*na*	*50.0*	*0.05*	*0.05*	*2.0*	*50.0*	*na*	*0.01*	*na*	*20.0*	*250*	*na*	*na*	*3.0*
*ADWG'96**	*6.5-9.2*	*4.0*	*20.0*	*0.05*	*na*	*1.50*	*na*	*0.10*	*0.30*	*1.2*	*0.005*	*50.0*	*0.05*	*0.05*	*2.0*	*50.0*	*na*	*0.01*	*na*	*20.0*	*250*	*na*	*na*	*3.0*
*AHSDWG'05**	*7.0-7.5*	*0.1*	*10.0*	*0.005*	*na*	*0.015*	*0.005*	*0.03*	*0.015*	*0.2*	*0.005*	*25.0*	*0.005*	*0.005*	*2.0*	*25.0*	*0.01*	*0.005*	*na*	*10.0*	*100*	*0.05*	*0.005*	*0.015*
Results																								
W413	0.00	0.040	0.04	0.005	0.003	0.009	0.021	0.003	11.86	0.000	0.003	0.15	0.020	0.017	0.257	0.32	0.021	0.052	0.58	2.03	1610	0.047	0.002	0.0
W414	0.00	0.002	0.00	0.004	0.008	0.004	0.064	0.002	0.000	0.000	0.000	0.0	0.001	0.011	0.028	0.12	0.019	0.042	0.13	0.40	2.24	0.040	0.001	0.0
W415	0.00	0.078	28.83	0.003	0.027	0.002	0.019	0.000	6.951	0.000	0.118	15.8	0.534	0.010	0.000	4.89	0.021	0.092	6.31	51.79	144	0.316	0.065	0.0
W416	0.00	0.032	4.79	0.001	0.001	0.002	0.005	0.000	0.081	0.000	0.003	9.6	0.019	0.000	0.003	0.08	0.000	0.003	3.91	11.30	7.80	0.116	0.026	0.0

Toxic Elements (Class 1) - Toxic according to level - ppm (mg/kg; mg/l)

Guidelines	Al	Au	As	Ba	Bi	Br	Cs	Ga	Nb	Pt	Sn	Te	Tl
*WHO**	*0.10*	*na*	*0.007*	*0.70*	*na*	*na*	*na*	*na*	*na*	*na*	*0.02*	*na*	*na*
*ADWG'96**	*0.10*	*na*	*0.007*	*0.70*	*na*	*na*	*na*	*na*	*na*	*na*	*0.02*	*na*	*na*
*AHSDWG'05**	*0.015*	*0.005*	*0.001*	*0.10*	*na*	*na*	*na*	*na*	*na*	*na*	*0.005*	*na*	*0.005*
Results													
W413	0.561	0.056	0.160	0.004	0.035	98.88	49.97	0.010	0.000	0.027	0.001	0.051	0.004
W414	0.005	0.026	0.024	0.004	0.023	113.2	83.33	0.022	0.006	0.000	0.019	0.046	0.003
W415	3.062	0.105	0.038	0.019	0.000	41.3	49.53	0.005	0.000	0.020	0.011	0.017	0.003
W416	0.313	0.051	0.000	0.047	0.000	0.0	0.00	0.000	0.000	0.009	0.000	0.000	0.004

Toxic Elements (Class 2) - Toxic at any level - ppm (mg/kg; mg/l)

Guidelines	Sb	Be	Cd	Pb	Hg	Ni	Ag	Tl	Th	W	U
*WHO**	*0.003*	*na*	*0.002*	*0.01*	*0.001*	*0.02*	*0.10*	*na*	*na*	*na*	*0.02*
*ADWG'96**	*0.003*	*na*	*0.002*	*0.01*	*0.001*	*0.02*	*0.10*	*na*	*na*	*na*	*0.02*
*AHSDWG'05**	*0.001*	*0.001*	*0.001*	*0.001*	*0.000*	*0.001*	*0.001*	*0.005*	*na*	*0.005*	*0.005*
Results											
W413	0.015	0.000	0.000	0.043	0.000	0.009	0.006	0.027	0.005	0.009	0.222
W414	0.015	0.000	0.000	0.031	0.006	0.005	0.000	0.028	0.003	0.013	0.270
W415	0.027	0.001	0.000	0.010	0.000	0.085	0.000	0.024	0.010	0.001	0.215
W416	0.000	0.000	0.000	0.000	0.000	0.028	0.001	0.002	0.009	0.000	0.072

Other Elements

Cl

Special Caution: Iron, Copper and Zinc are normally nutritional elements, however in drinking water they can be corrosion derived free radicals and thus can be toxic elements by behaving as free radicals.

Discussion: The ADWG 1996 only covers a small spectrum of elements. The ADWG 1996 does not distinguish between organic chelated elements of the type found in ordinary foodstuffs and metallic ions, and bases its recommendations on known safe dietary levels of the various elements. The ADWG 1996 also fails to differentiate safe chelated cation levels and safe ionic cation levels. This is an entirely fallacious basis for setting an acceptable level because a signifcant toxicity occurs from the ingestion of ionic metals which the body is not evolved to transport without significant and replete levels of organic compound derived element levels, ie. organo chelate compound cations.

A constant low level source of ionic aluminium, copper or zinc can substantially disrupt cell metabolic processes initiating a broad range of disease whereas optimum chelated cation levels are necessary for wellness, anti-aging and disease resistance. This has necessitated evolving a much more stringent set of guidelines for drinking water. These are called Alternative Health Sciences Drinking Water Guidelines 2005 (AHSDWG 2005)

***Abbreviations:tr** - trace; **na** - not available at this time; **WHO** - World Health Organisation; **ADWG'96** - Australian Drinking Water Guidelines 1996; **AHSDWG'05** - Alternative Health Sciences Drinking Water Guidelines 2005*

Macro & Trace Elements: Boron B, Calcium Ca, Chromium Cr, Cobalt Co, Copper Cu, Germanium Ge, Iodine I, Iron Fe, Fluoride F, Lithium Li, Magnesium Mg, Manganese Mn, Molybdenum Mo, Phosphorus P, Potassium K, Rubidium Rb, Selenium Se, Silicon Si, Sodium Na, Sulphur S, Tin Sn, Strontium Sr, Vanadium V, Zinc Zn

Toxic Elements (Class 1) - (Toxic according to level): Aluminium Al, Gold Au, Arsenic As, Barium Ba, Bismuth Bi, Bromide Br, Caesium Cs, Gallium Ga, Niobium Nb, Platinum Pt, Tin Sn, Tellurium Te, Titanium Ti

Toxic Elements (Class 2) - (Toxic at any level): Antimony Sb, Beryllium Be, Cadmium Cd, Lead Pb, Mercury Hg, Nickel Ni, Silver Ag, Thallium Tl, Thorium Th, Tungsten W, Uranium U

Other Elements: Chloride Cl;

Alternative **Health Sciences**

FRANK PARSONS, Scientist; PO Box 271, North Geelong. Vic 3215 Phone 03 5229 7200 Fax 03 5229 7201

W413-W416

As with the Acid Sulfate Soil testing the water test results are indicative only. From this one off test there may be a case for further analysis of the soil and water in the Boomerang Swamp as indicated by elevated levels of aluminium, strontium, vanadium, and uranium.

The Swamp 2010.

The tier area surrounding the south side of the Swamp.

Ferns dead and plant invasion of drier tolerant vegetation , 2010.

Site 78 looking east.

Vegetation giving the bluey tinge in the shot above.

2011, deep cracks within the Swamp.

Dry peaty soil down to 900 mm.

June 2012 after the fire reduction burn earlier in the year

This shot was taken in early September 2012 after three wet winters.

Page 81 shows a panoramic shot at the same site taken after a month of regular heavy rainfall.

Site 79 after the fuel reduction, looking south. Shot taken June 2012.

77

This star picket was placed here in 2008. This photograph was taken in 2012 before the swamp was covered in water in September 2012. Note there is no sign of corrosion after 4 years.

Looking north from the tier.

Looking back into the tier.

6 October 2012. First time the Boomerang Swamp was covered with evidence of surface water for over a decade.

Site 78 looking west.

6 October 2012 after an extremely wet September.

26 November 2012 and the swamp water had dropped considerably.

8 January 2013. Other photographs can be seen in Appendix 5.

These two shots have been taken at the same location just west of Site 78. Pre flooding of the swamp in late September this isolated small fern area was lush and thriving. For some reason once this area was inundated the ferns died.

83

This shot shows vigorous vegetation growth. It will be very interesting to see what happens in this area into the new year – see Appendix 5.

The galvanised droppers at Sites 78 & 79 showing corrosion up to the high water level.

Some of the trees that had invaded Site 79 have toppled over since the fire and inundation.

Some metres into the swamp this interesting photograph was taken.

The Big Swamp – similarities to Boomerang Swamp. (See pages 6 & 49 for the Big Swamp location.)

In many respects the scenario at the Big Swamp is very similar to the management that has taken place at the Boomerang Swamp. Since Otway Water Book 17[14] was written new and revealing material has come to light further highlighting the deplorable manner in which the demise of the Big Swamp has been handled.

The relevance of this in relation to Boomerang Swamp is simple and clear cut, both sites are on the Barongarook High, both fall well within the residual drawdown effects and impacts from the groundwater extraction at the Barwon Downs Borefield, and both situations have been handled badly.

The following time line of events depicts a most interesting story.

1993
Stream flow gauging indicated a persistent and alarming drop in pH levels in the water of Boundary Creek.

2004
Barwon Water had its licence to extract groundwater at the Barwon Downs Borefield renewed. Part of the licence conditions was to monitor water sensitive wetlands with possible groundwater connectedness. A flora study of such sites had to be completed within 5 years – 2009.

August/September2008
Test results carried out by Deakin University, Warrnambool, indicated water coming from the Big Swamp was extremely acidic and contained toxic metal and metalloids.

October 2008
Barwon Water was notified that test results indicated serious acid problems within the area of residual drawdown from their borefield at Barwon Downs. On 10n October ABC Stateline television ran a 10 minute grab on this very issue. The Barwon Water CEO was interviewed as

part of this television presentation. Barwon Water was aware and had been fully briefed by the Landcare Group, LAWROC, of data collected indicating a serious acid problem within the Board's sphere of influence.

November 2008

Southern Rural Water was notified of and given copies of these test results indicating that the Big Swamp was an Actual Freshwater Inland Acid Sulfate Soil site.

Before Barwon Water's 2008-09 Flora Survey Commenced ...17 December 2008.

Chris Hughes of Southern Rural Water was asked, among other things, what action was being taken in regard to the acid and heavy metals levels being detected in the Big Swamp. Part of his reply included this[17]...

> ***"In accordance with condition 7 of the licence, SRW has required Barwon Water to undertake a detailed Flora Survey. Barwon Water has sought tenders from suitably qualified expert consultants and the successful tender has not yet been appointed. Barwon Water must consult with the Department of Sustainability and Environment regarding suitable consultants. The investigation into Acid Sulphate soils will be incorporated into the consultant's analysis and the completed report is expected by mid-2009."***

This letter was quite specific and the assurance that the Big Swamp would be included in the Flora Survey was most welcomed.

In 2012 several queries were sent to Chris Hughes asking why the Big Swamp was not included in the Flora Survey. Eventually a reply came from Angus Ramsay who was given the responsibility to reply. His letter was dated 2nd July 2012. An extract from this letter is as follows...

> ***"Thank you for your email of 11th June 2012 requesting information regarding the investigation into Acid Sulfate Soils at the Big Swamp being included in a Flora Study being undertaken on behalf of Barwon Water relating to the Gerangamete groundwater licence.***
>
> ***At the time of our response letter of 17th December 2008, Southern Rural Water and Barwon Water were finalising the scope of the study and had included Acid Sulfate Soil's as one of the aspects to be looked at.***
>
> ***It was determined that the issue of Acid Sulfate Soils in the area was too large and specialised to fit within the scope of the study and the team assembled to undertake the flora based study. The study team did visit a location outside of the study area that was showing aspects of Acid Sulfate Soil's, but as the team didn't have any expertise in this area, they weren't able to offer a considered opinion on the issue."*** It would appear that the Big Swamp initially had been included in the Flora Survey but was at a later stage omitted because of a lack of expertise that SKM brought to the study. What feeble excuses and who made the decision to exclude the Big Swamp?

In 2011 the Department of Primary Industries, Victoria, tabled a report, Acid Soils and Soil Acidification in Victoria – a review, written by Crawford, Heemskerk and Dressel. These experts were prepared to have a shot at the issue even if SKM and Southern Rural Water thought that it was outside their area of expertise or responsibility. This quote is taken directly from this report.

Quote One. ***"It is understood that in Boundary Creek, AASS has been created by an unsuccessful attempt to extinguish the fire by draining the peat."*** (AASS – Actual Acid Sulfate Soil)

The main objective of the Barwon Water Flora Survey was to determine the ***impacts*** on any Groundwater Dependent Ecosystems within the Barongarook High Region. The Big Swamp most definitely satisfied this criteria, was easily reached, was, up to the 1980s a permanently saturated and healthy wetland and in recent times exhibited serious impacts that could not be denied. From Quote One above it would appear that there was some justification in leaving the Big Swamp out of the Flora Survey. In fact, such a notion of fire activities being suggested as the cause of the Actual Acid Sulfate Soils may have prompted Barwon Water to finally tackle and make comment on such a ***"large and specialised"*** issue. In Barwon Water's question and answer section of the Water Supply Demand Strategy 2012-2062 can be found the following:

Quote Two

Q. What is the cause of acid sulfate soils at Big Swamp on Boundary Creek at Yeodene?

A. A range of factors are likely to have contributed to changes at this site, including:

- **an outbreak of fire on the swamp in 1997 which started in an adjacent private property**
- **extensive drainage works conducted for fire management purposes**
- **extensive on-site fire management burning within the swamp to reduce fire risk**
- **an extensive drought between 1997 and 2009.**

There are many issues raised in these two quotes but it should be most obvious that you do not drain peat to extinguish a peat fire, nor does one carry out fuel reduction burns within a dry peat area. Both of these notions presented above are nonsense and display a high level of ignorance regarding the behaviour of peat fires. It is interesting to note that after the 1997 fire had supposedly been extinguished it surfaced again in 1998 and then smouldered for another 12 years before surfacing and causing another serious wild fire in 2010.

Perhaps the best people to ask about fire behaviour to clarify the wild accusations made by the Department of Primary Industries and Barwon Water would be those people accused of causing the Actual Acid Sulfate Soils of the Big Swamp. The Colac branch of the Country Fire Authority was asked to comment on the two quotes cited above.

Subject: Reply to acid sulphate letter

From: Brian Brady (B.Brady@cfa.vic.gov.au)

To: otwaywater@yahoo.com.au;

Date: Tuesday, 24 April 2012 2:45 PM

Hi Malcolm, in response to the two quotes in your letter.

Quote 1..Draining the peat was never considered an option by CFA or any of the organisations that have been in a supporting role in dealing with this situation, it is certainly not documented as a control option, in fact it is quite the opposite to what we considered early on in the event and that was to flood the area, not to drain it.

Research has since indicated that the drier the peat the greater chance of it self combusting so draining it is not an option.

Quote 2..point two and three regarding the "drainage works" conducted, as in the first quote response, there were no drainage works conducted, the trench that was constructed was done so to create a physical break in the continuity of the peat so that it would burn to an edge and run out of "available fuel" when it reached the break. CFA have no technical expertise in draining swamps nor was any sought and, as above, draining the swamp would create more problems than it would have solved.

There was no fuel reduction burning (fire management burning in the quote) in the swamp area whatsoever. The area burnt within the swamp was that consumed during the two main fire events that occurred in the swamp area in October 1997 and March 2010.

One of the control strategies proposed after the 2010 fire was to burn out the dead vegetation within the swamp that had accumulated after the fire but this option was never acted on due to the fact that it may have set any unburnt peat alight and also it was considered too dangerous to have personnel walking on the peat surface in case the crust on the surface gave way and the personnel may have sunk into what may have been powdery ash under the crust which may still have been hot.

There is still the proposal to construct a clay plug along the eastern trench and part of the southern trench which is designed to increase the moisture level of the peat to prevent the peat drying out to the point of self combustion and to also extinguish any pockets of smouldering peat under the surface. The "plug" proposal is endorsed by Latrobe University and will be proceeded with if funding becomes available.

The matter of acid sulphate soils occurring after the fires and issues about the water table are completely outside CFA's scope of responsibility and expertise and therefore CFA will not involve itself in the resolution of these issues.

Regards

Brian Brady

The CFA reply...

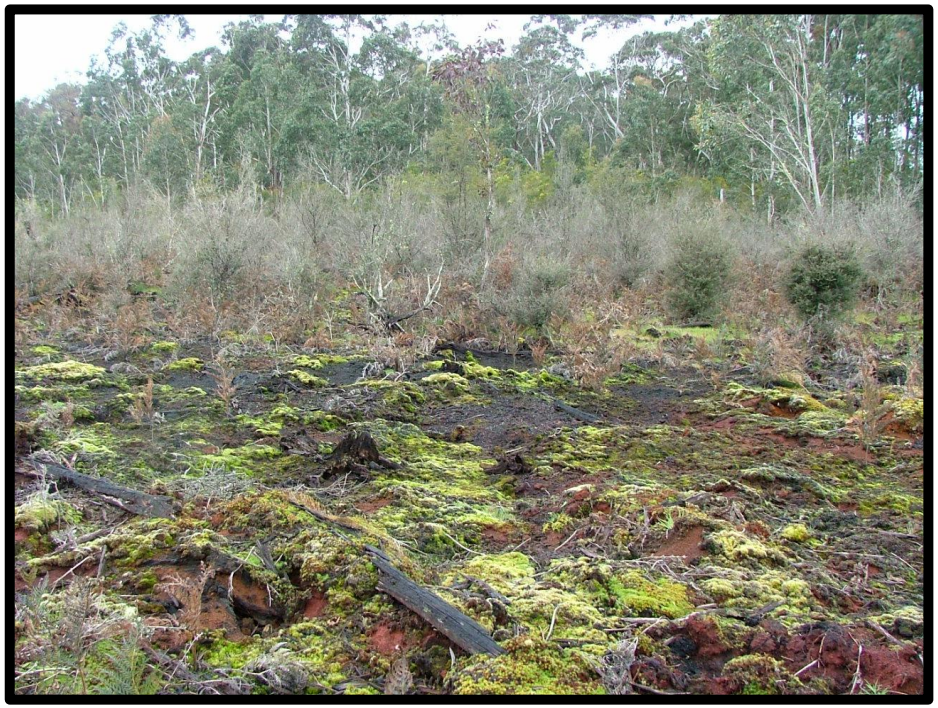
Interestingly the Big Swamp had initially been included as part of the 2008-09 Barwon Water Flora Survey and it is as interesting to note that Sinclair Knight Merz (SKM) the company conducting this survey, did not have the expertise to deal with the issue. This is most curious, especially when local Landcare Group, LAWROC, appeared to have more expertise than the "specialists." The LAWROC members were able to identify severe impacts and provide the necessary experts and resources to positively have the Big Swamp declare an Actual Freshwater Inland Acid Sulfate Soil Site with the distinction of having a soil sample test out as one of the worst top three samples found in Australia. What is more alarming is that SKM with all the resources at its disposal, is Barwon Water's major consultant of the Barwon Downs Borefield development and management and could not assess the state of the Big Swamp.

To make matters worse the Big Swamp was visited during the conducting of the Flora Survey and is located closer to the Barwon Downs Borefield than the majority of the original 84 flora sites surveyed in 1993-94. Was the Big Swamp left out of the Flora Survey on Purpose? It looks that way.

The following pictures show the star picket that was placed in the Big Swamp during this visit and the visual impact this site would have presented to those doing the survey. How could this site be ignored? The impacts are obvious to the most casual observation.

The following pictures give a glimpse at the scene the Flora Survey "expert" would have seen.

It is my guess those people visiting this site would have been horrified and it was someone else that ordered the omission of this site from the survey.



Whether the "***team***" had the expertise to deal with acid sulfate soils or not when visiting this site, alarm bells should have rung loud and clear that this wetland had been subjected to a dramatic detrimental influence of some kind. The obvious degradation effects on the water dependent vegetation in this swamp was the very thing that the Flora Survey was aimed at investigating. How or why this site was dropped from the survey is beyond belief.

4 March 2009

The flowing extract is from a letter sent from the Water Minister, Tim Holding, of the time **(DSE Ref: DSE063402, File: CS/07/3073)**.

> ***"BW recently completed a flora study as part of the monitoring requirements of the groundwater extraction licence it has for Barwon Downs. Whilst acid sulphate soil (ASS) monitoring was outside the scope of the study, no evidence of acidification was found. Nonetheless, BW is now proposing to work with agencies to specifically investigate ASS impacts at local and regional sites."***

This response prompted a formal complaint being sent to Southern Rural Water.

A similar letter of formal complaint was sent to all of the statutory authorities including the Department of Sustainability and Environment (DSE), that had been approached over the demise of the Big Swamp asking that some action be taken.

3 May 2009

This extract forms part of the letter[(25)] from Peter Harris the then Secretary of DSE(His Ref: SEC005476, File CS/03/0445-3)...

> ***"In preparing the Barwon Downs licence in 2003/04, extensive hydrogeological and ecological investigations occurred. An independent panel considered that all identified wetlands in the area were sustained by a local shallow water table not connected to the regional groundwater resource that supplies the borefield. The panel recommended that the licence require Barwon Water undertake flora surveys to further investigate the connection between riparian vegetation and groundwater levels.***
>
> ***BW commissioned a flora study*** (2008-09) ***as part of the monitoring requirements of its groundwater extraction licence. Acid Sulphate soil (ASS) monitoring was outside the scope of the study, however no evidence of acidification was found. Nevertheless, BW is now proposing to work with agencies to specifically investigate ASS impacts at local and regional scales."***

11 May 2009

Peter Harris's letter prompted this reply...

Mr. Peter Harris
Secretary
Department of Sustainability and Environment
8 Nicholson Street
PO Box 500

East Melbourne
Victoria 8002

Dear Mr. Harris

Re; Groundwater Extraction at Barwon Downs.

95

Thank you for your reply to my formal complaint regarding the ASS,
Your Ref. SEC005476,
FILE CS/03/0445-3.

There are some points that you make in your reply that indicate that you are not being given up to date advice.

1. *In spite of the protracted drought of 12 years there are streams and wetlands in the adjoining areas to the Barwon Downs borefield that are not being influenced like the wetlands of Boundary Creek. The groundwater extraction at Barwon Downs is causing serious problems along Boundary Creek.*
2. *Yes BW does release water out of its Colac to Otway pipeline into a tributary of Boundary Creek. But this most definitely does not address the impact on flows in Boundary Creek.*
3. *The area called the Big Swamp on Boundary Creek where the ASS is, seldom sees any of this released water.*
4. *The trigger level for release of this water into Boundary Creek has been exceeded for years and all that this water does is exasperate the ASS problem.*
5. *Unfortunately the extensive hydrological and ecological 2003/04 investigations that you refer to, must not have been looked at by the independent panel. The 14 May 2003 SKM "Recommendations for Groundwater Licence Conditions" quite clearly delineates that the wetlands in the Big Swamp on Boundary Creek have a direct connection to the EVF aquifer that BW is extracting groundwater from. For you to be advised that "...all wetlands in the area were sustained by a local shallow water table not connected to the regional groundwater resource that supplies the borefield" is almost beyond belief. The reports are available that quite clearly indicate the opposite.*
6. *The reason for the trigger level that implements releases from the Colac Otway pipeline is set at 158.5 AHD. It was set at 158.5 AHD because the hydrological investigations clearly stated that if the watertable dropped to 158 AHD the wetlands in the Big Swamp would begin to dry out. The AHD has been way below this level for years, consequently the production of acids and releases of toxic heavy metals – AASS into the Big Swamp area.*

7. *Adjoining aquifers most definitely have not suffered 50 m drawdown like at Barwon Downs.*
8. *Water Data Victoria pH levels for Boundary Creek clearly show the dramatic increase in toxic acid levels that should have triggered investigations years ago. Someone has not being doing their job of scrutinising the effects of groundwater extraction.*
9. *You talk of the early 2000s ecological investigations but it would appear that you were not informed that these studies began in 1986. Parts of the studies and their recommendations that have not been implemented. Your advisers would appear to have an extremely limited knowledge of these studies and their implications.*
10. *Yes the ASS may have been outside the scope of the 2009 flora study just completed. However the site was visited and the ASS should have been most apparent to the consulting team that finalised the study, considering the composition and expertise of this team.*
11. *What I find most disturbing is that DSE consultants on this team, indicated that when there was discussion on the ASS, this aspect of the study was not to be included the final report.*

I would appreciate you letting me know the reasons why officers from your Department insisted that any mention of the ASS was not to be included in this 2009 Carr flora study report?

I would also like to know why the Colac Otway Shire was not asked to have a representative on this consulting team.

I believe that you cannot make adequate decisions if your advisors are not fully informing you of all the facts. A site visit would seem most appropriate, preferably with your advisors present so that you can see for yourself and gain first hand knowledge information. I would recommend that if you plan to make a site visit that you invite me along as your guide.

I once again lodge a formal complaint that groundwater extraction at Barwon Downs is causing serious Actual Acid Sulfate Soils in the wetlands of the Big Swamp on Boundary Creek and that immediate site investigations should take place.

Yours sincerely,

Malcolm Gardiner

11-05-2009
PS I have included a few pages with water sample results of water along Boundary Creek. (PP 41, 63-66 Bk (8))

16 July 2009

Over two months later, a reply arrived from the Secretary and more startling revelations were revealed (reply is found on page 98).

- As long as Barwon Water adhere to the licence conditions everything is in order and any suggestion of things to the contrary can be ignored.
- A compensation water release of a maximum 700 ML/year into the depleted aquifer is seen as adequate when 12000 ML/year is being extracted.
- Thoughts and discussion regarding different water compensating releases have remained just that for over three years, thoughts and no evidence presented that any discussion has taken place.
- Yes, there is evidence of other Actual Inland Acid Sulfate Soil sites appearing within the catchment but Peter failed to add that they ALL fall within the area of residual drawdown from the Barwon Downs Borefield.
-

Peter Harris, in his first reply stated that all identified wetlands in the area were not connected to the aquifer Barwon Water was pumping from. The fifth paragraph of his letter below, states exactly the opposite.

If it is accepted by Peter that Boundary Creek is connected to the deep water aquifer it also has to be accepted that many of the swamps along Boundary Creek are connected to this aquifer and the Boomerang Swamp is in the headwaters of one of the tributaries to Boundary Creek.

- One of the "***suitable licence conditions***" that SKM made in the late 1990s was that the Permissible Annual Volume should be set at 4000ML/year and not be exceeded. Despite this limit the licence given to Barwon Water was set at 20000 ML/year, five times greater than the level of anticipated and acceptable environmental impacts.
- It may have been characteristic that the Barwon River and other streams across the Barwon River Catchment had dried up but it was not the characteristic of the Gellibrand River Catchment a catchment that was outside the direct influence of the Barwon Downs Borefield.

Department of Sustainability and Environment

Ref: SEC005678
File: CS/07/3073

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Mr Malcolm Gardiner
1805 Colac Beech Forest Road
KAWARREN VIC 3249

Dear Mr Gardiner

GROUNDWATER EXTRACTION AT BARWON DOWNS - FURTHER CORRESPONDENCE

Thank you for your letter dated 11 May 2009 regarding acid sulphate soils (ASS) at Big Swamp, Boundary Creek.

Southern Rural Water (SRW) is the licensing authority responsible for administering Barwon Water's (BW) licence to extract at Barwon Downs. SRW is satisfied that BW is adhering to its licence conditions including the release of a compensation flow into Boundary Creek. The flow is released when groundwater reaches 158.5 AHD (as stated in your letter) in the relevant observation bore.

The condition requires that a constant flow is released equating to two million litres. To enhance the benefits of the compensation release BW has proposed investigating the release of this water in flushes, rather than at a constant rate. It is considered that this may provide a more 'natural' flow for the creek. Should this be established BW would have to provide evidence to SRW that such an approach would be environmentally beneficial and the licence conditions would need to be amended.

The continuing dry climate is impacting water resources across the region. Stream flows have declined over the past 12 years. During the last 12 months, record low stream flows have occurred in a number of rivers across the region, including the Barwon River, which ceased to flow for a number of months during summer. This was repeated across the catchment, with many ephemeral streams having little or no flow through the whole year. The same trend is evident in wetlands with Lake Gnarpurt, classified as permanent under the Corrick classification system, drying out in recent times.

The connectivity of Boundary Creek and the Eastern View Formation aquifer is not in dispute. This is in fact the reason why the compensation flow condition, mentioned above, was included to BW's licence.

In regard to pH levels in Boundary Creek, it would take a comprehensive study to establish if changes to pH were the result of climate change or groundwater extraction. Sulfidic sediments which remain in saturated anaerobic conditions are not usually a problem and are termed Potential Acid Sulphate Soils. However, if exposed to air the impact of ASS can be significant. Evidence of the development of ASS in the other parts of the catchment are starting to appear and it is again unclear whether the prolonged dry conditions or the pumping of groundwater are key factors.

Assessing the impacts of ASS in the region falls under the responsibilities of the Department of Primary Industries (DPI). A mapping project has been proposed to look at statewide occurrences of ASS and the processes involved. This will allow DPI to identify whether ASS are caused by climate change or by other local influences for specific sites.

Officers from the Department of Sustainability and Environment (DSE) keep track of all studies relevant to the region. Investigations into the Barwon Downs borefield began in 1968 with a study of the groundwater potential of the region by S. Hancock. The first report which focussed solely on the environmental considerations of water resource use in the region is the 1986 report you mention by Quentin Farmar-Bowers. The recent SKM study "Recommendations for Groundwater Licence Conditions" was commissioned for the purpose of assessing BW's licence and provided adequate scope to determine suitable licence conditions.

As you are aware BW had to produce a flora study under the conditions of its licence. The findings of the flora study were formally presented to SRW and the Corangamite Catchment Management Authority, organisations with direct interest in the sustainable management of water resources in the region. Your assertion that officers from this department would direct the findings of an independent study commissioned by another body is unfounded.

Thank you again for raising this matter with me.

Yours sincerely

PETER HARRIS
Secretary

16/7/09

- Someone made the decision not to include the Actual Inland Freshwater Acid Sulfate Soil site of the Big Swamp in the findings of the 2008-09 Flora Survey,
- despite Southern Rural Water insisting that it be included.
- Peter's Department had to be consulted regarding suitable consultants to do the work and his Department was fully aware of the issues involved.
- Considering the survey did not have to be finished until the end of 2009 there appeared to be an uncharacteristic rush by Barwon Water to complete the survey and publish the results by April 2009.

Have lies been told and perpetuated, is the Big Swamp and Boomerang Swamp demise just a case of incompetence, a problem too hard to deal with or just a situation whereby authorities believe they can say and do whatever they want with no fear of having to be held accountable for what they say and do? You be the judge.

The similarities with the demise of the Boomerang Swamp indicates that there needs to be a monumental shift with the manner of management practices.

Unfortunately many of the same policies, management practices, people, officials and government departments are presently involved in considering the connecting of the Colac Otway Pipeline water supply system into the Barwon Downs Borefield.

CONCLUSION

Tardiness, lack of expertise, paucity of data, decades of failure to implement recommendations and an over ruling need and attitude that the greater city of Geelong and it's populace are more important than an isolated region of the Otway Ranges all contributed in varying degrees to environmentally destructive decisions.

As far back as 1982 Barwon Water has been extracting large amounts of groundwater from its Borefield at Barwon Downs. This Borefield is officially known as the Gerangamete Borefield. The detrimental drawdown from this Borefield has been dramatic and is most noticeable in the recharge area of the Barongarook High. Even after two years of no pumping the residual drawdown levels are still in the order of thirty metres under the actual Borefield and ten metres in the region of the Boomerang Swamp (as reported by Barwon Water in 2011-12).

Between 1982 and August 2010 over 120000 ML of water had been extracted from the Borefield. In the most extensive and comprehensive study done up to date on this Borefield it has been calculated that the extraction of 1500 ML/Yr would have no effect on groundwater to surface water dependent ecosystems. This report took over four years of detailed study to compile and was released in 1995.

This same report determined that the recharging capacity to the aquifer from the rain falling on the sands of the Barongarook High was in the order of 4000 ML/yr. It was therefore calculated that an extraction of 4000 ML/yr was a reasonable amount and an amount that would have acceptable and tolerable impacts upon the surface water systems. In fact the Permissible Annual Volume (PAV) was set by the Government of the day at 4000 ML/yr in October 1997. One month before this Barwon Water began pumping, exercising an extraction licence issued two

years earlier for 12000 ML/yr. Despite this PAV limit of 4000 ML a renewal of the 12000 ML/yr licence was increased and a 20000 ML/yr licence was issued in 2004.

Over the 1982 and August 2010 period and under normal weather conditions and at a recharging ability of 4000 ML/yr the rain falling on the Barongarook High would have amounted to 112000 ML that would have naturally infiltrated back into the aquifer. This natural recharging ability was 8000ML short of what had been extracted. However, taking out 13 years of severe drought exacerbated the situation and the most optimistic recharge back into the aquifer from rainfall would have been approximately 60000 ML. This meant that groundwater had been extracted much faster than it was being replenished, in the order of 60000 ML.

It could be argued that this shortfall of recharge explains why after three wet winters up to September 2012 and two years since pumping ceased and when all water storages and reservoirs throughout the region were full to overflowing, Boomerang Swamp remained dry. Hoxley's(SKM) postulation of 2002 proved to be totally wrong when he stated that Boomerang Swamp would recover faster than the regional groundwater levels. It would appear that Boomerang Swamp was not sitting on its own perched aquifer but appeared to be connected to the aquifer that Barwon Water was pumping from.

As early as 1986 it was recommended that vertical leakage investigations within the Barongarook High Region be started so that the connectedness between aquifer and surface groundwater dependent ecosystems could be determined. No such study has ever taken place even though it was recommended again in 1994, 1995, 2001, 2003, and 2008.

In this same 1986 report prepared by Farmar-Bowers, he had made many other recommendations for a series of environmental studies to be implemented that would provide the data necessary to make informed environmental management decisions. Farmar-Bowers made these recommendations along with the following predictions

- The pumping of the Barwon Downs wellfield is likely to create changes in groundwater levels of the order of 25 to 50 metres at the site.
- Aquifer pumping during droughts, as is proposed, would tend to exacerbate the effect of natural variation by extending the effects of drought.
- If there is a deficit of natural flow into wetlands over an extended period some of the environmental changes will have become entrenched and will not be easily reversed.
- Changes may occur quite rapidly within a few years.

- Some of the Boundary Creek riparian area is swamp with fine mud, rich in organic matter several metres deep.
- The saturated zone may shrink in size.
- Aquatic vegetation at spring and swampy areas may be affected as these areas dry out.
- In most of the areas, the change may be gradual, one habitat being replaced by another, however in the wetter areas, (riparian zones adjacent to springs and wet areas), the change may be quite rapid.
- The area has a low agricultural and timber production value as soil fertility is low and some low lying areas are often waterlogged.

Farmar-Bowers completed his series of environmental study recommendations before the commencement of the extensive 1987 test pump at the Barwon Downs borefield. The brief for his report was to determine what environmental studies should be completed before this test began and also attempt to assess the likely environmental impacts. Farmar-Bowers's series of recommendations were never implemented and after the 1987-1991 test pump a licence for Stage One extractions was granted for 12000 ML/yr.

In 2003 when reviewing the groundwater extraction leading up to the Stage Two licence a section dealing with two swamps, including Boomerang Swamp formed part of the draft licence conditions. This draft included implementing data collection measures that were designed to study the interconnectedness between the Boomerang Swamp and the deep water aquifer. At last. Unfortunately though, this whole section was deleted from the new licence conditions based on assumptions, generalisations, guess work and assertions that the Boomerang Swamp was sitting on its own perched aquifer and had little to no connection to the deep water aquifer. Any connection was dismissed out of hand based on some terrible advice. Whether this ill founded direction came from lack of research, funding or time constraints, lack of expertise or as the most expedient way to proceed will never be known. But whatever the reason it was later stated quite explicitly in the 2008-09 research conducted by the same company, SKM, that there was such a paucity of data available that there were no areas within the Barongarook High that could be accurately described as containing a perched aquifer. The assertions of five years earlier that significant decisions were based on in 2002-03 were founded on this paucity of data and in hindsight can at best be described as wild guess work.

Similarly it was pure conjecture made by Hoxley(SKM) when he stated that the Boomerang Swamp most likely had dried up in earlier droughts as far back as the 1920s. There is not the smallest piece of evidence to support this assertion. If anything, what little evidence there is indicates the exact opposite.

In 1994 Boomerang Swamp was visited by Carr of Ecology Australia as part of a flora study leading up to the issuing of the 12000 ML/yr groundwater extraction licence in 1995. This study was attempting to determine those sites within the suspected drawdown area that had hydrological sensitive ecosystems, areas that relied on wet and or saturated conditions that may be connected to the deep water aquifer.

Boomerang Swamp was identified as a possible site. At the time this swamp was also recognised as a site of State Botanical Significance. The vegetation identified at this site relied on and required saturated conditions to thrive and survive. This vegetation species group was not known to exist anywhere else in the region. As this peat swamp dried out these water dependent species began to be replaced by vegetation tolerant to drier conditions. Another one of Farmar-Bowers predictions coming true.

The multitude of yabby skeletons scattered across the parched swamp was indicative of a lack of water over an extended period. The fact that the yabbies had died and complete skeletons could be found on the surface suggested that their usual habit of deep burrowing at certain times of the year to avoid any lack of surface water had been interrupted. A possible explanation for this trauma could be the high levels of acidity produced as the peat began to oxidize and be infrequently rewetted. A change in acidity would also be stressful to flora within the swamp. The swamp has been assessed for acid sulfate soils and this initial investigation indicates borderline Actual Acid Sulfate Soils problem prompting the need for further thorough study.

As late as June 2012 the Australian Government National Water Commission in its "*Assessing water stress in Australian catchments and aquifers*" report made it abundantly clear that decisions arrived at when determining the renewal of groundwater extraction licences (such as the one at Barwon Downs in 2003) have been made based on very poor scientific foundations. If data is not collected then conjecture, modelling and guess work become the accepted, the norm. To overcome this problem of a paucity of data, each time there is a review of this work and recommendations are then made to better assess impacts and management procedures, these recommendations should be implemented. They should not left as words in a report gathering dust on a shelf. Too many of the recommendations made regarding environmental studies for the Barongarook High Region have been gathering decades of this dust.

This Australian Water Commission report found that one of the most apparent obstacles to returning overallocated or overused systems to environmentally sustainable levels of extraction was the reluctance by authorities to public acknowledge overuse and overallocation of the water resources. The Barwon Downs Borefield would appear to be one such example. Without a declared acceptance that mistakes have been made nothing will improve.

Another issue stated in the Water Commission Report was the lack of definition given to terminology and criteria. Because there was no uniformly accepted definition of terms and criteria being used there was little chance that what was being described in one situation could be adequately compared to another. There appeared to be no conformity, and words such as "overuse" could have a variety of meanings depending on the authority using the term. This has most definitely been the case with the term "sustainability" and its use in relation to groundwater extraction from the Barwon Downs Borefield.

The Commission also found that there needed to be improved monitoring and assessment to gain a better understanding of Australia's water resources and that groundwater data was poorly represented. Interestingly though, it was found the "*Excessive extraction from confined aquifers* (such as the deep waters aquifer at Barwon Downs) *will lead to lowered pressure-heads and reduced discharge to connected GDEs*." (GDEs - groundwater dependent ecosystems). There is every indication that Boomerang Swamp is a GDE and has suffered from a poor understanding of the water resource being exploited at the Barwon Downs Borefield. The Water Commission report further states that an SKM (2012) attempt to assess water stress on groundwater was not successful. SKM has been Barwon Water's major consultant advising on the management of the Barwon Downs Borefield for decades and it would appear doesn't have the necessary data available to assess the effects from groundwater extraction on GDEs. In fact a 2008-09 flora study conducted by SKM on behalf of Barwon Water concluded that the reasons for detrimental impacts on hydrological sensitive vegetation in the Barwon Downs Borefield area of influence could not be conclusively determined, Barwon Water released a media report stating that results of the report were inconclusive and that further studies were required. Three years later and still these studies have not been undertaken. And, surprisingly these recommendations mirror ones that have been repeated in many reports and still have not been implemented.

Those decisions made back in 2002-03 regarding the care and management of Boomerang Swamp have to be seriously questioned and any planning for further studies should once again include Boomerang Swamp. It is long past time that some serious data collection on how this borefield is managed in relation to GDEs be implemented and that it be based on the numerous recommendations that have been repeatedly made to Barwon Water over the decades but never started. Necessary data to make informed and scientifically based decisions for managing environmental impacts as a result of groundwater extraction must be gathered.

Also, an essential component in this process has to be comprehensive definitions of terms used so that there can be no confusion or mistakes made as to the reasons for and meaning of decisions arrived at. Uniformity of terms throughout the groundwater extraction industry would also enable Australian wide comparative data.

Being a signatory to the 2004 National Water Initiative, the State Government of Victoria has given prominence to improve management of groundwater. Considering the way in which the Boomerang Swamp has been managed and the volume of data collected by the community Landcare Group, LAWROC, indicating that something is terribly wrong with the management of the Barwon Downs Borefield, it is long past the time whereby the licence for this Borefield requires a dramatic and comprehensive review.

Barwon Water July 2000 under Assessment of Issues.
"*Little monitoring is available to confirm vertical leakage.*"

Statements found in the draft Licence Conditions of 2003 that were never included in the final licence.

1."*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 6, page 104)**

2."*... the extent to which vegetation is dependent on continuous high groundwater levels is not known.*'

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

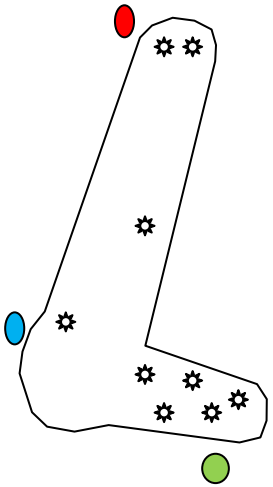
Too much guesswork, too little data collection.
Far too rushed, too little caution.
Too many assumptions, too few facts.
Too many generalisations and guess work, not enough specifics.
Too many experts, too little judgement.
Too many unknowns, too little concern.
Too many mistakes, and by far
.....too little recapitulation.

APPENDIX ONE

The Concern with the Image in PLATE 9 of the Carr and Muir 1994 Report.

When attempting to find an area that could be producing the acid water found in a tributary of Boundary Creek above the Big Swamp , aerial photographs, charts and maps were closely scrutinised. There were several swamps found within the target area but by far the largest and easiest to recognise was the Boomerang Swamp. By punching in the co-ordinates of survey sites identified in the Carr and Muir 1994 report, Sites 78 and 79 landed at either end of this swamp. Being such a large area and perhaps the easiest swamp in the area to locate it was decided to investigate Boomerang Swamp first.

There can be no doubt that Sites 78 and 79 lie at either end of Boomerang Swamp. The Boomerang Swamp and Sites 78 and 79 are one and the same location. However, every time Plate 9 was perused there appeared to be something not quite right. The image seemed to be of the wrong configuration and did not fit neatly with local knowledge and other images. The swamp appeared to be facing the wrong way. Using the flip horizontally mode on the image had a dramatic effect and the image then made sense. The following pages indicate that the negative used to depict Boomerang Swamp was in fact back to front.



Fattened heel

trees

Skinny short end of Boomerang Swamp with trees (2011) growing into the swamp.

Plate 9. Aerial view of the State significant swamp dominated by Fine Twig-sedge (*Baumea arthrophylla*) featured in Plate 7.

PLATE 9

The shadows on this image indicate that north is either in the direction towards the left hand side of the page (North/South shadows), to the top of the page (West/East shadows) or to the bottom of the page (East/West shadows).

SOURCE: Carr & Muir 1994.

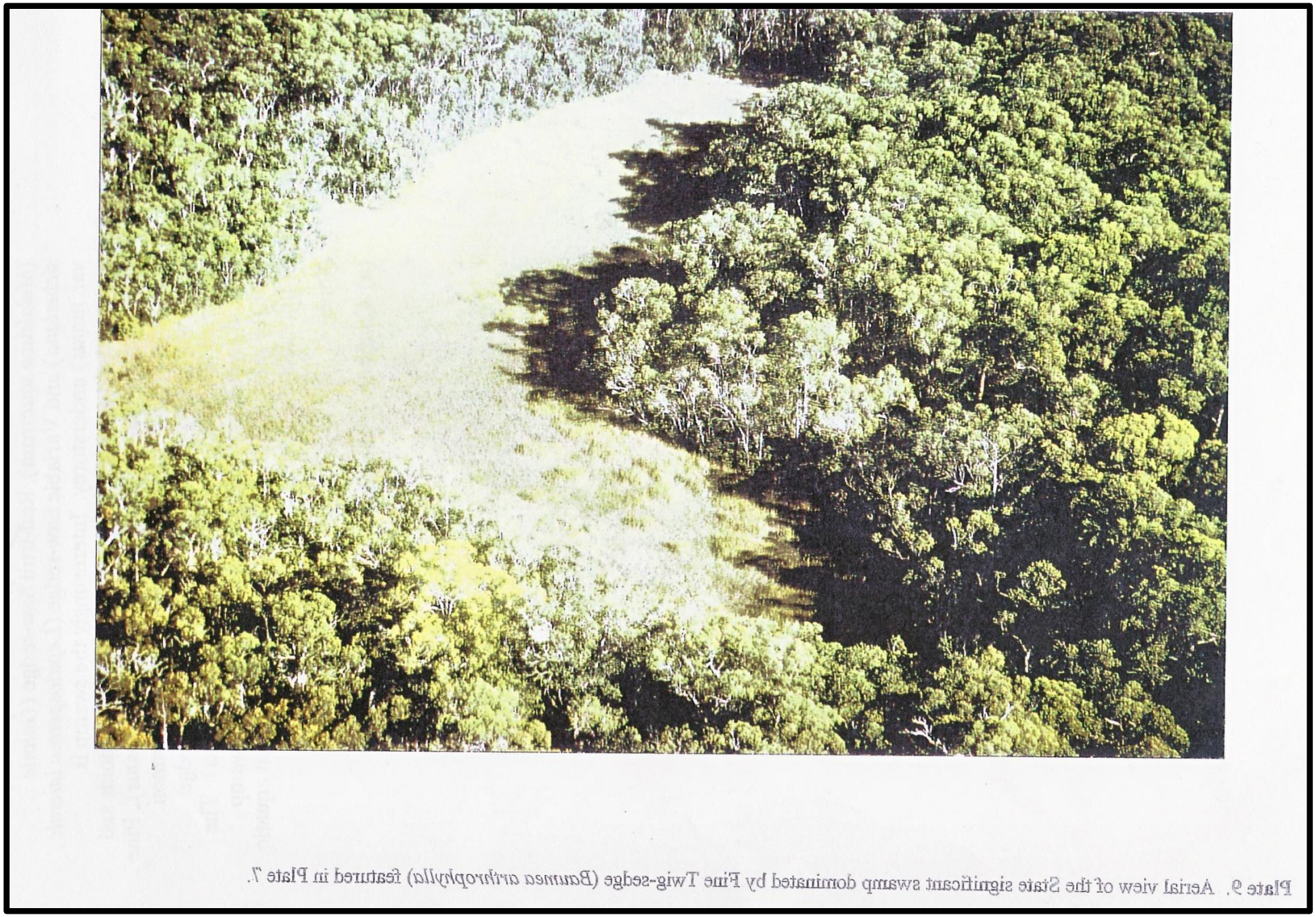


Plate 9. Aerial view of the State significant swamp dominated by Fine Twig-sedge (Baumea arthrophylla) featured in Plate 7.

However, if this same image is flipped horizontally it is no longer confusing and matches all of the other images of this swamp.

With north to the right hand side of the page the shadows would fall as expected.

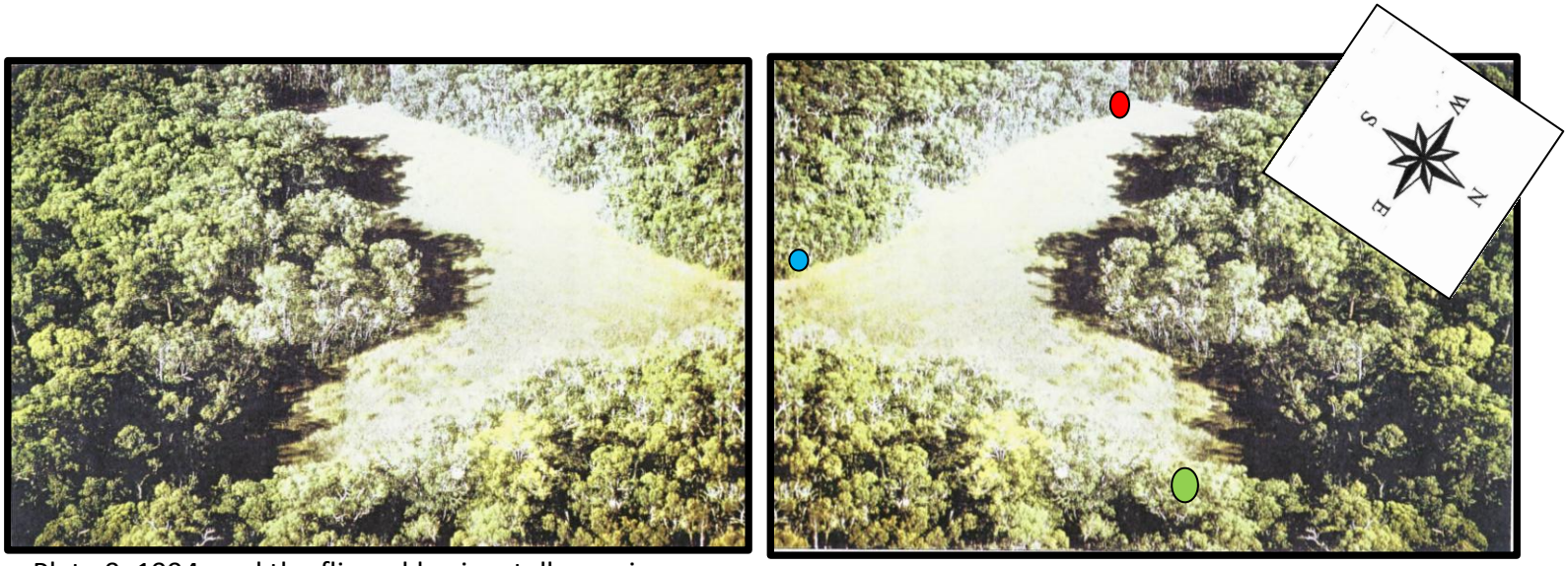
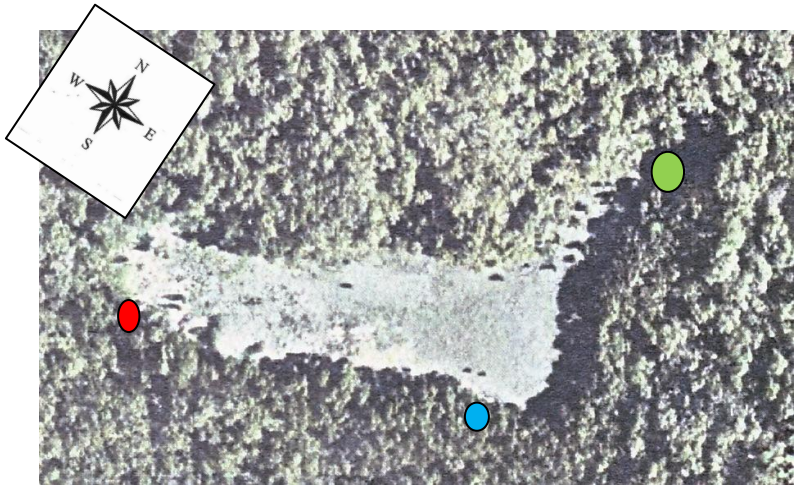
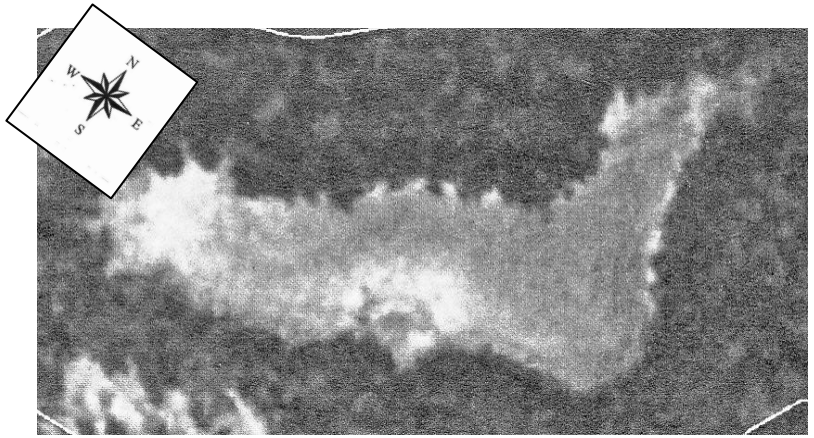


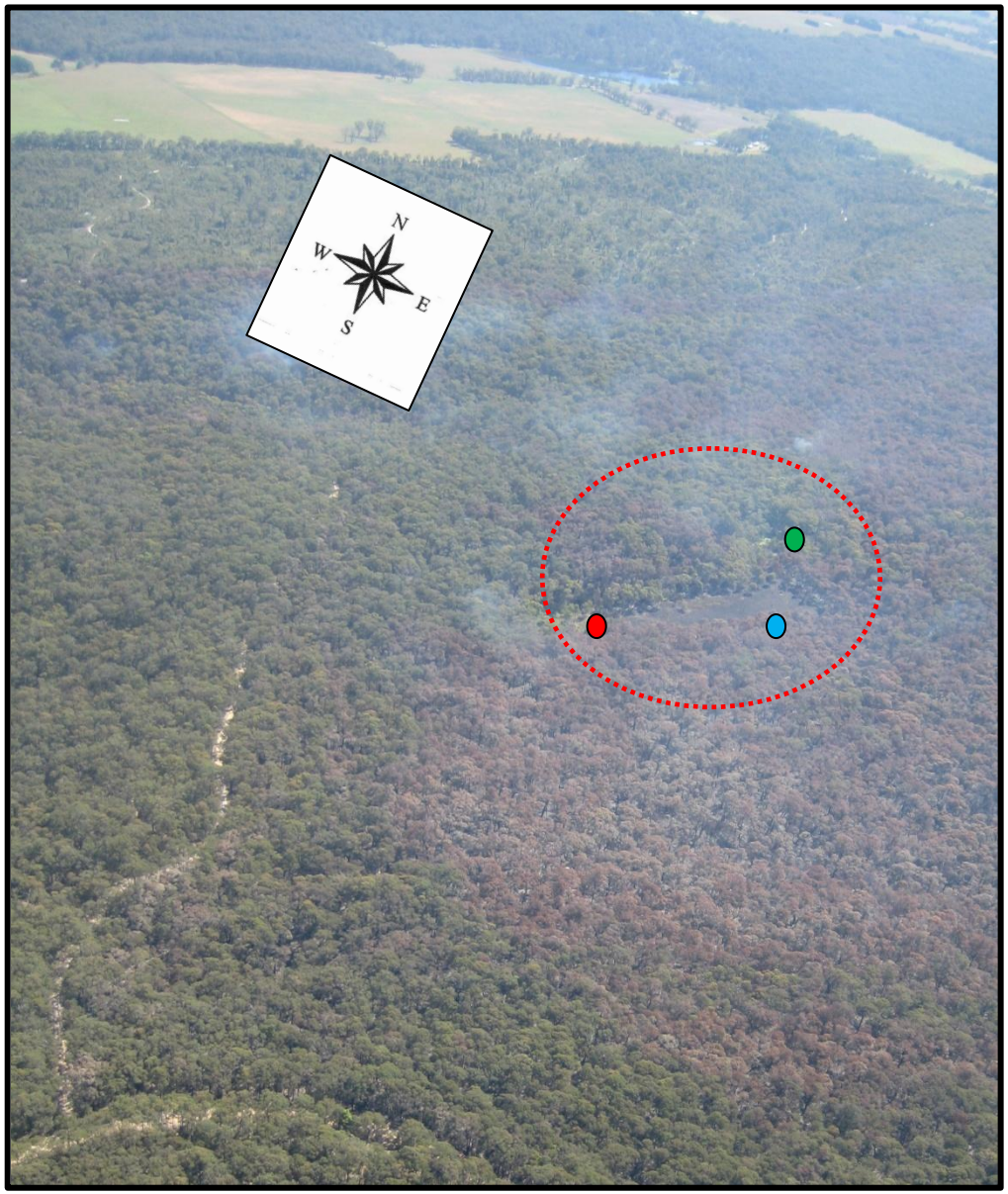
Plate 9, 1994, and the flipped horizontally version.



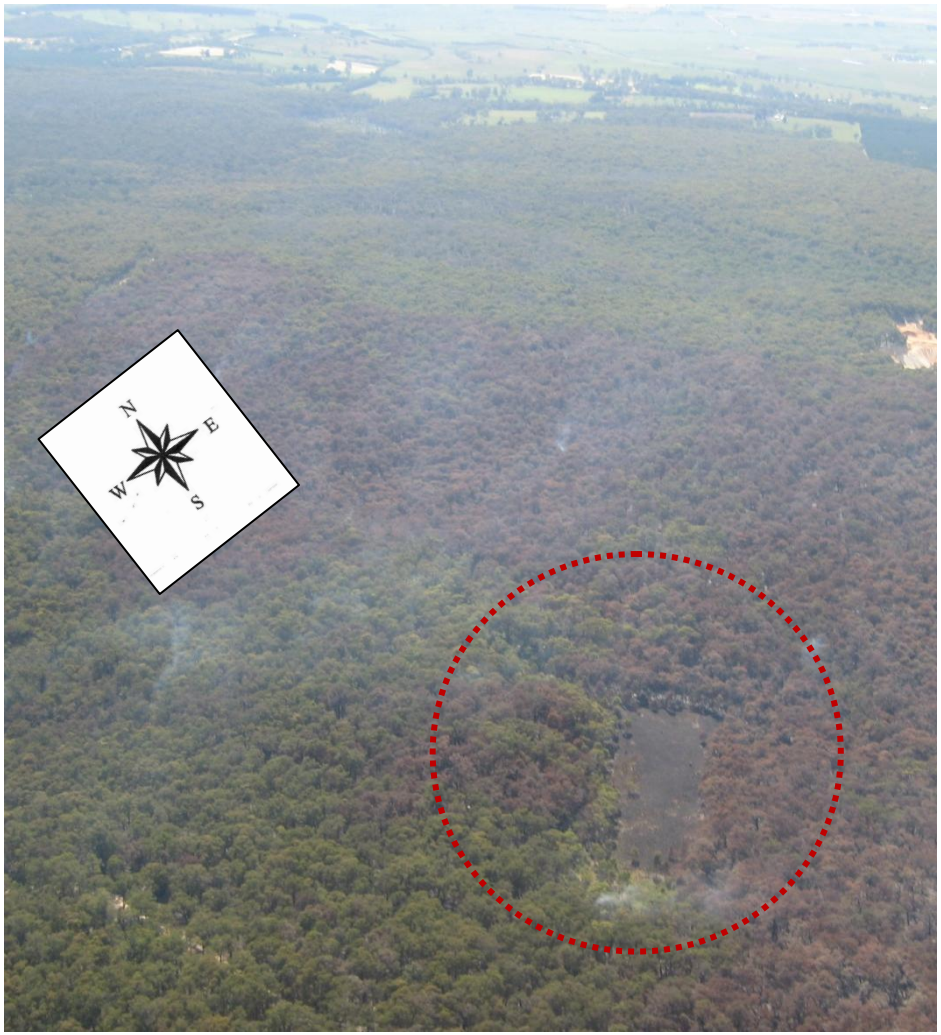
2007

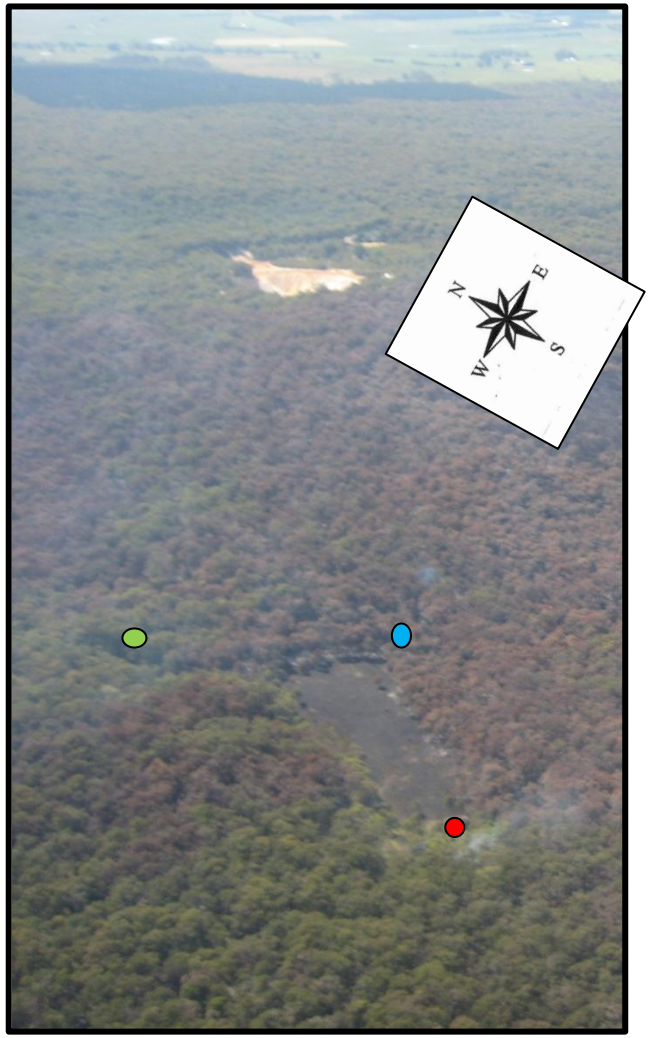


1940



Photographs taken during the 2012 fire reduction burns.



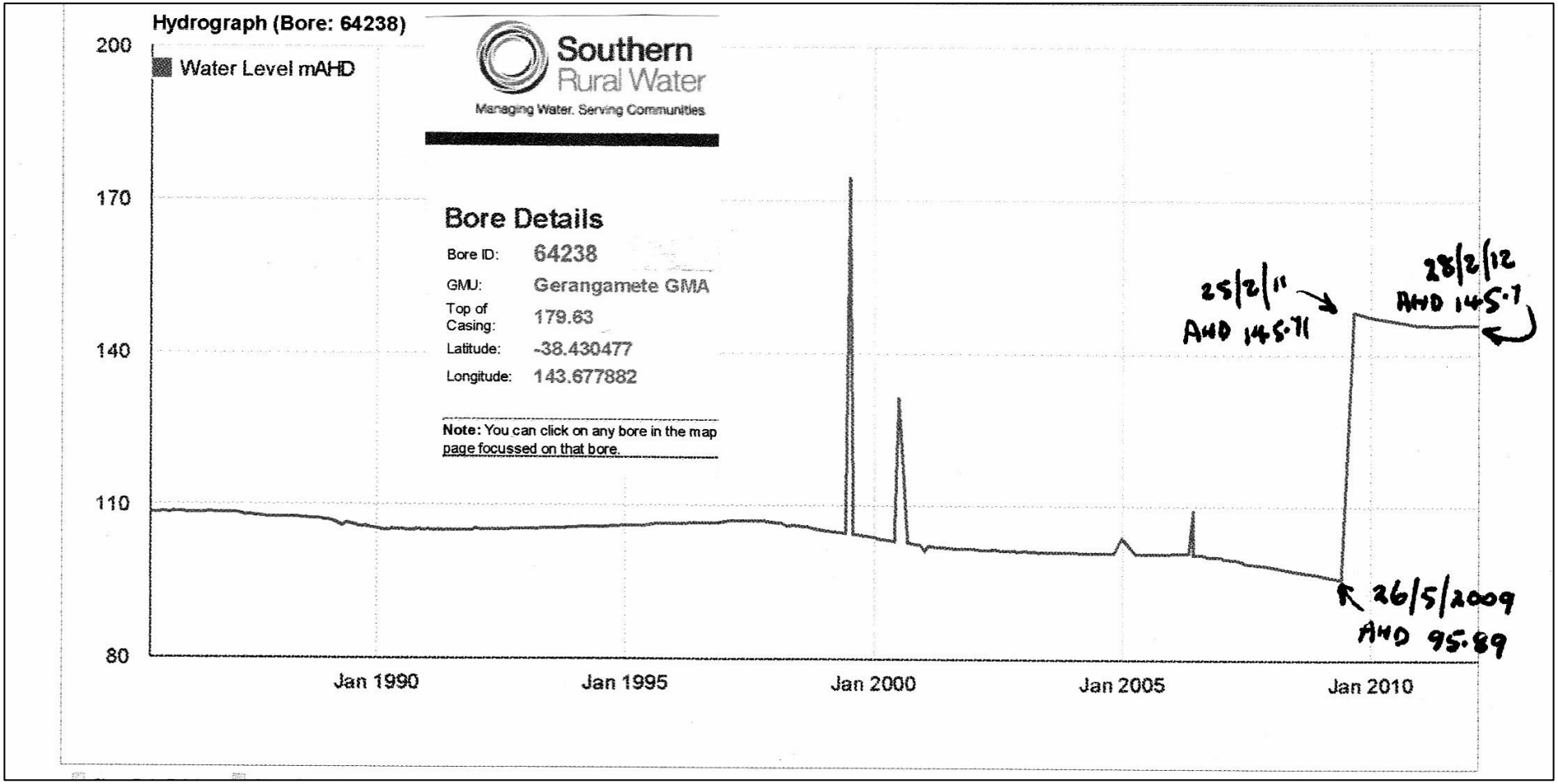


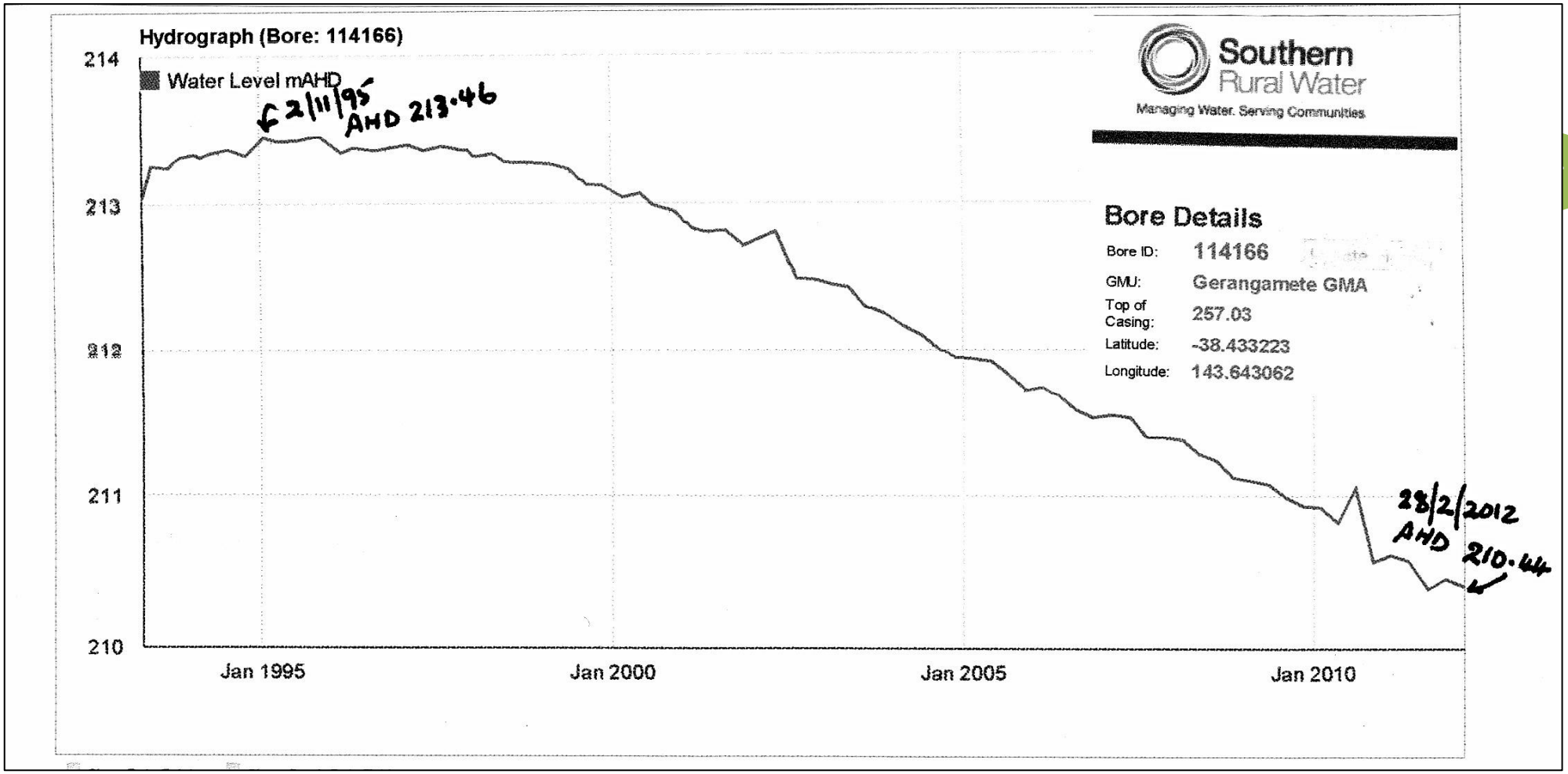
Including all of these images does seem to be labouring the point that Plate 9 in the Carr & Muir 1994 flora survey incorrectly represents Sites 78 and 79. However, it does make it abundantly obvious that mistakes can be made even with the best intentions. In reality it matters little which way the Boomerang Swamp is represented. The important thing is that it is beyond dispute that it was once a swamp of State botanical significance.

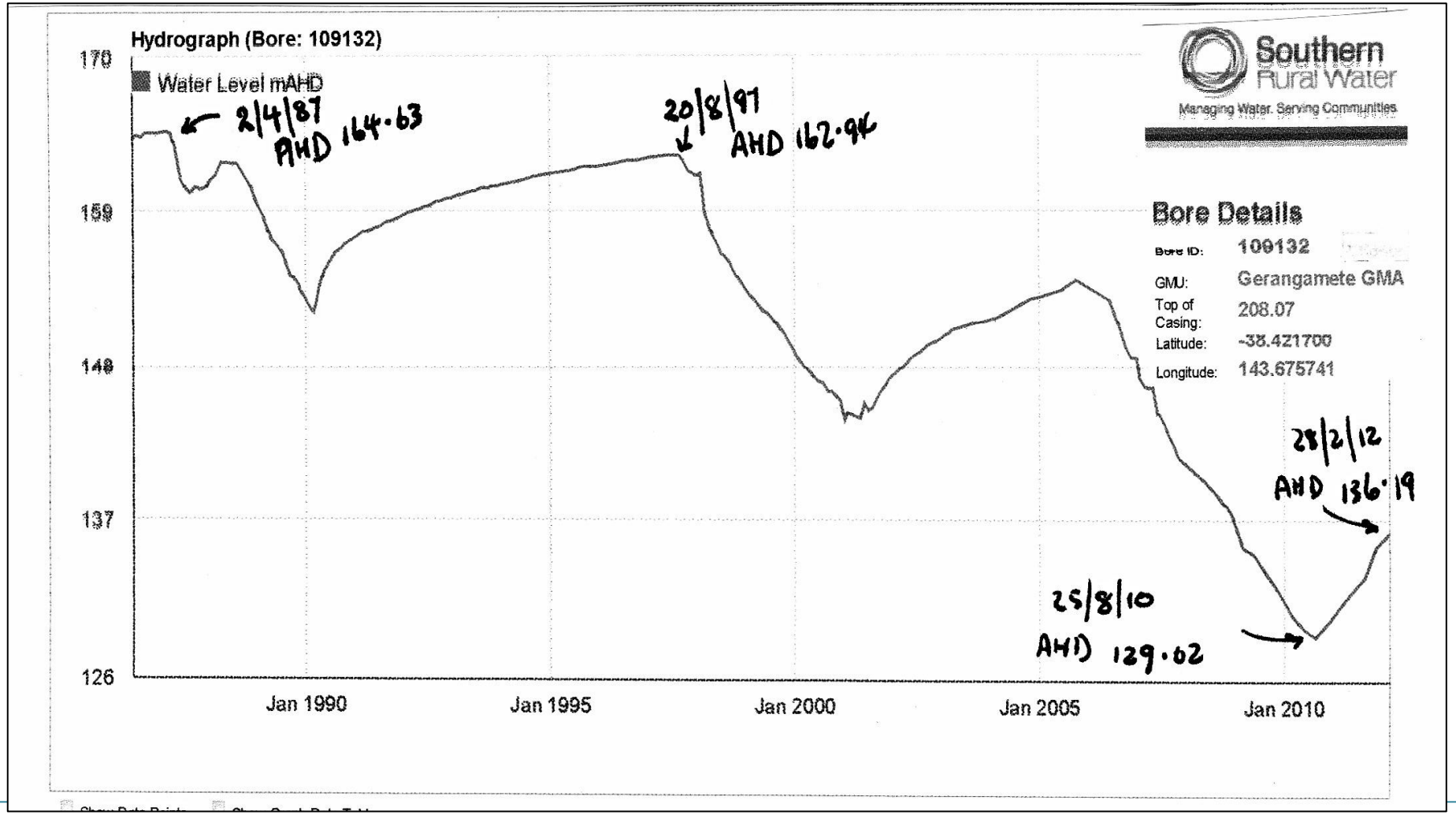
The reasons for its demise to a dried out peat swamp is a different matter all together. In all probability poor hydrological research, lack of data collection going back decades and ill-informed “expert” statements have lead to its demise.

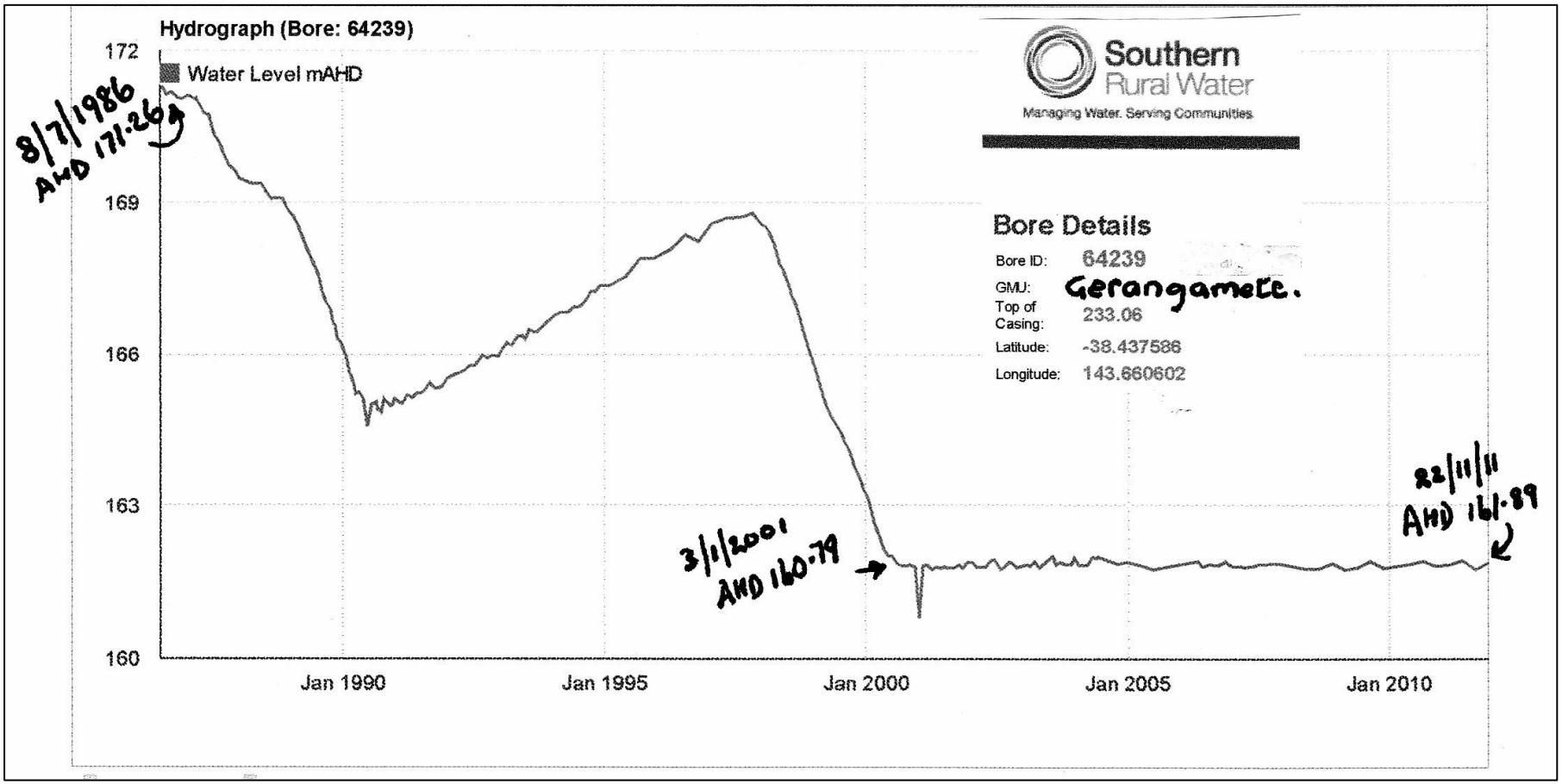
Perhaps Hoxley made a similar mistake stating that drawing down the deep water aquifer underneath Sites 78 and 79 would have no effect on Boomerang Swamp.

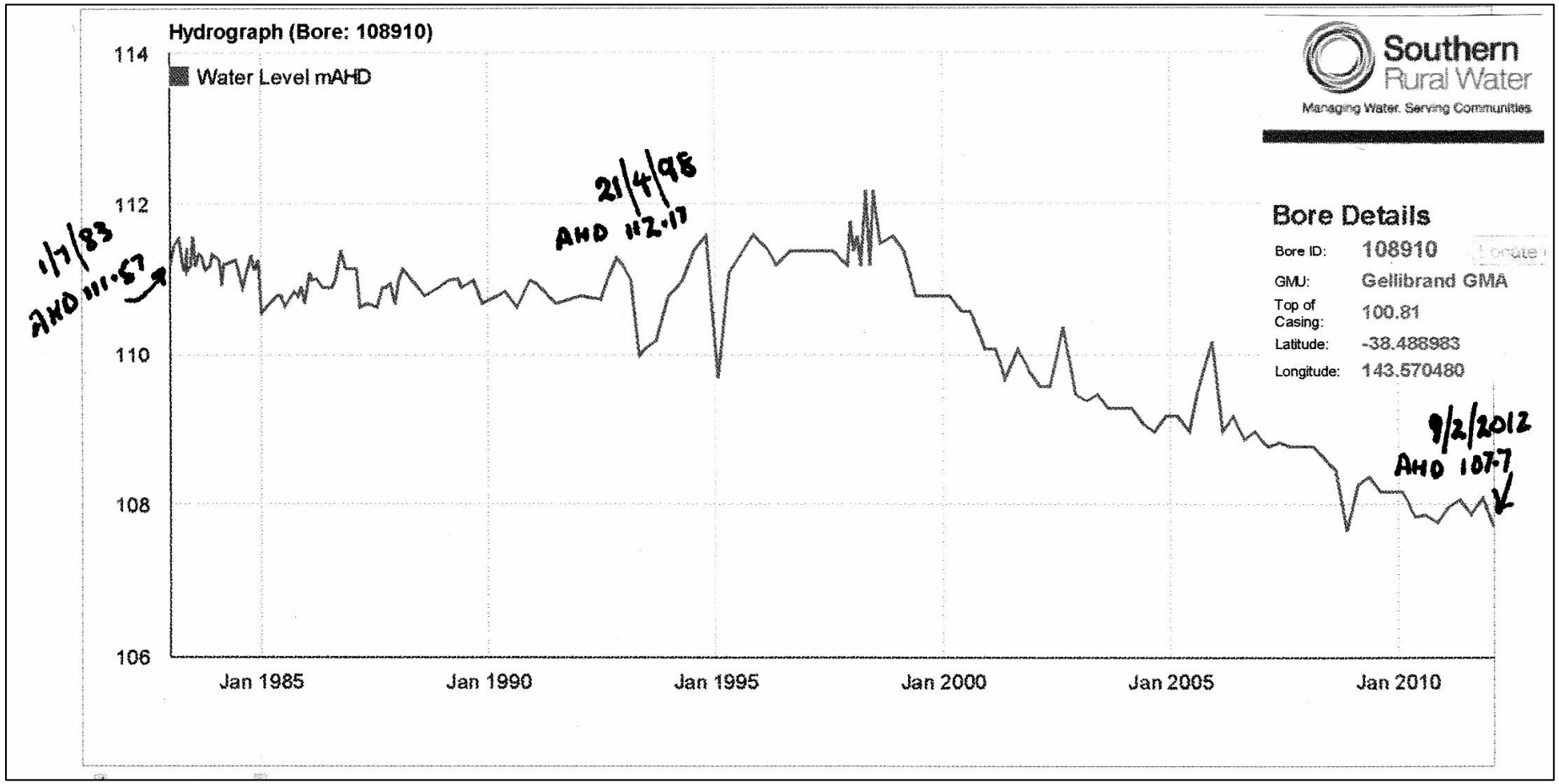
APPENDIX TWO

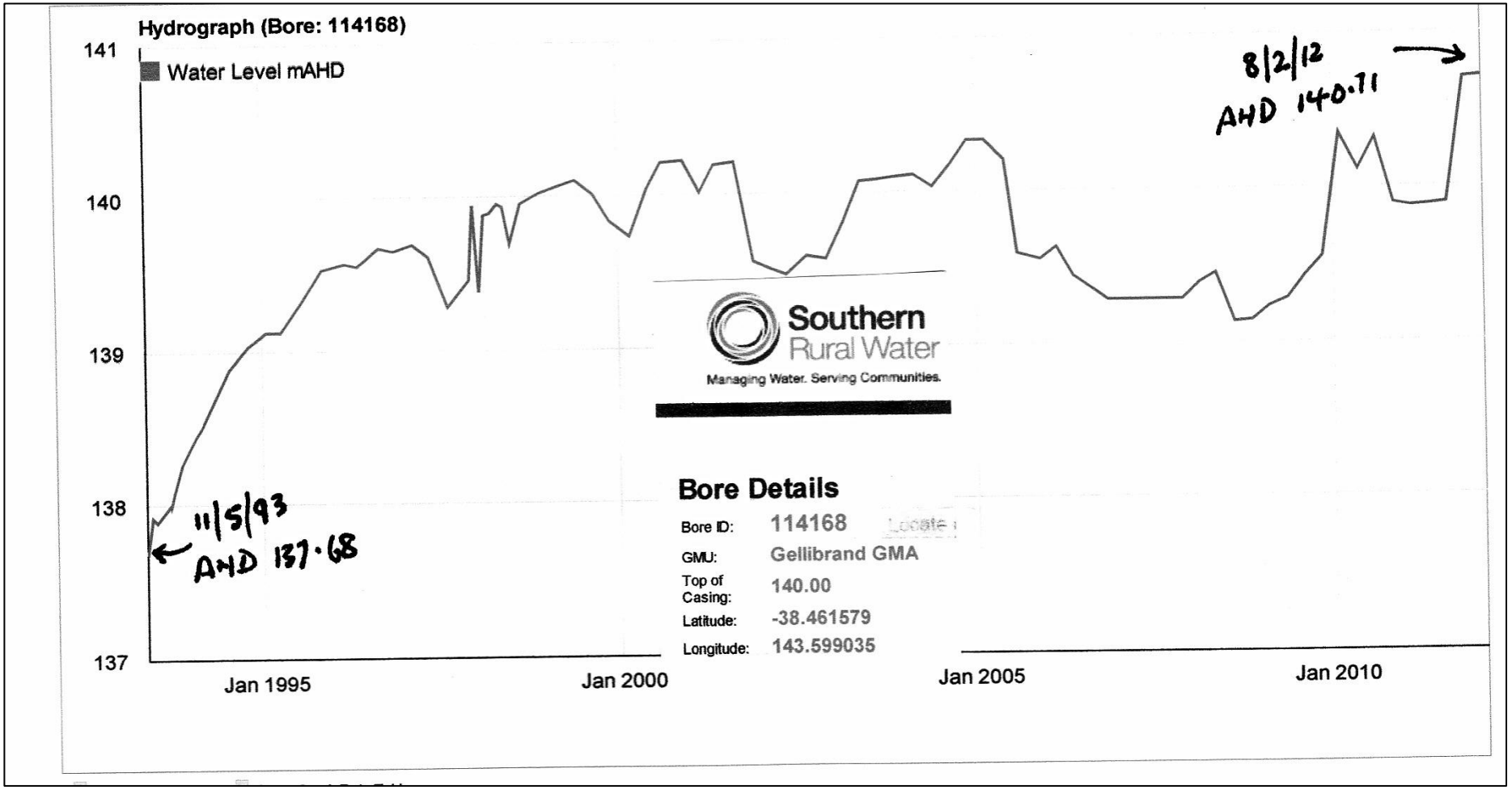



Hydrograph (Bore: 114166)
Water Level mAHD
214
213
212
211
210
Jan 1995
Jan 2000
Jan 2005
Jan 2010
2/11/95 AHD 213.46
28/2/2012 AHD 210.44
Southern Rural Water
Managing Water. Serving Communities
Bore Details
Bore ID: 114166
GMU: Gerangamete GMA
Top of Casing: 257.03
Latitude: -38.433223
Longitude: 143.643062


Hydrograph (Bore: 109132)
Water Level mAHD
170
159
148
137
126
Jan 1990
Jan 1995
Jan 2000
Jan 2005
Jan 2010
2/4/87
AHD 164.63
20/8/97
AHD 162.96
25/8/10
AHD 129.02
28/2/12
AHD 136.19
Southern Rural Water
Managing Water. Serving Communities.
Bore Details
Bore ID: 109132
GMU: Gerangamete GMA
Top of Casing: 208.07
Latitude: -38.421700
Longitude: 143.675741


Hydrograph (Bore: 64239)
Water Level mAHD
172
169
166
163
160
Jan 1990
Jan 1995
Jan 2000
Jan 2005
Jan 2010
8/7/1986
AHD 171.26
3/1/2001
AHD 160.79
22/11/11
AHD 161.89
Southern
Rural Water
Managing Water. Serving Communities
Bore Details
Bore ID: 64239
GMU: Gerangamete.
Top of Casing: 233.06
Latitude: -38.437586
Longitude: 143.660602

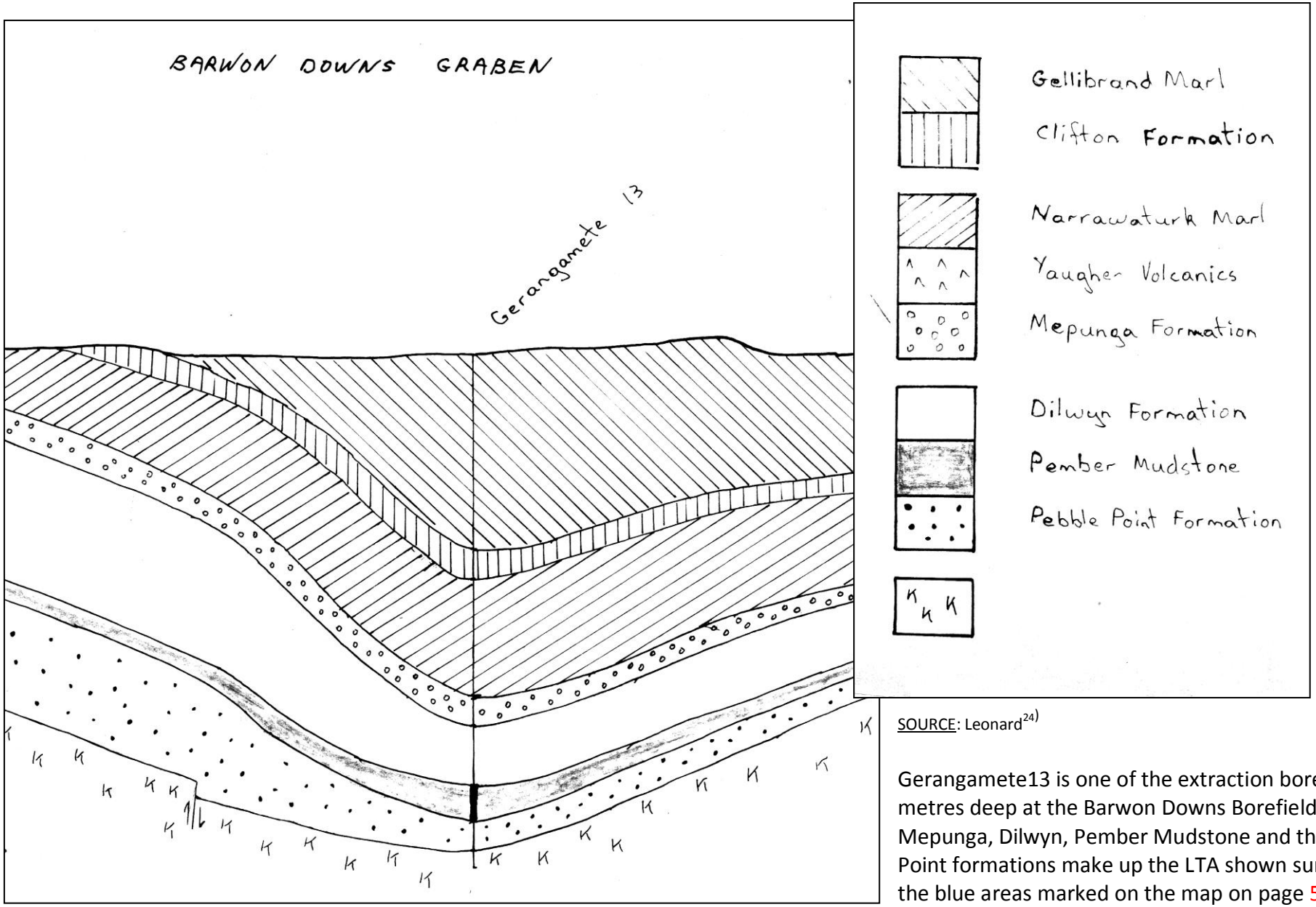

Hydrograph (Bore: 108910)
Water Level mAHD
114
112
110
108
106
Jan 1985
Jan 1990
Jan 1995
Jan 2000
Jan 2005
Jan 2010
1/7/83
AHD 111.57
21/4/98
AHD 112.17
9/2/2012
AHD 107.7
Southern Rural Water
Managing Water. Serving Communities
Bore Details
Bore ID: 108910
Locate
GMU: Gellibrand GMA
Top of Casing: 100.81
Latitude: -38.488983
Longitude: 143.570480


Hydrograph (Bore: 114168)
Water Level mAHD
141
140
139
138
137
Jan 1995
Jan 2000
Jan 2005
Jan 2010
11/5/93
AHD 137.68
8/2/12
AHD 140.71
Southern
Rural Water
Managing Water. Serving Communities.
Bore Details
Bore ID: 114168
GMU: Gellibrand GMA
Top of Casing: 140.00
Latitude: -38.461579
Longitude: 143.599035

APPENDIX THREE

Under the Freedom Of Information Act the document on pages 105-110, was obtained from Barwon Water (Barwon Water ref: F073478).This report contains similar graph plots from those found on pages 25, 29 and 30.

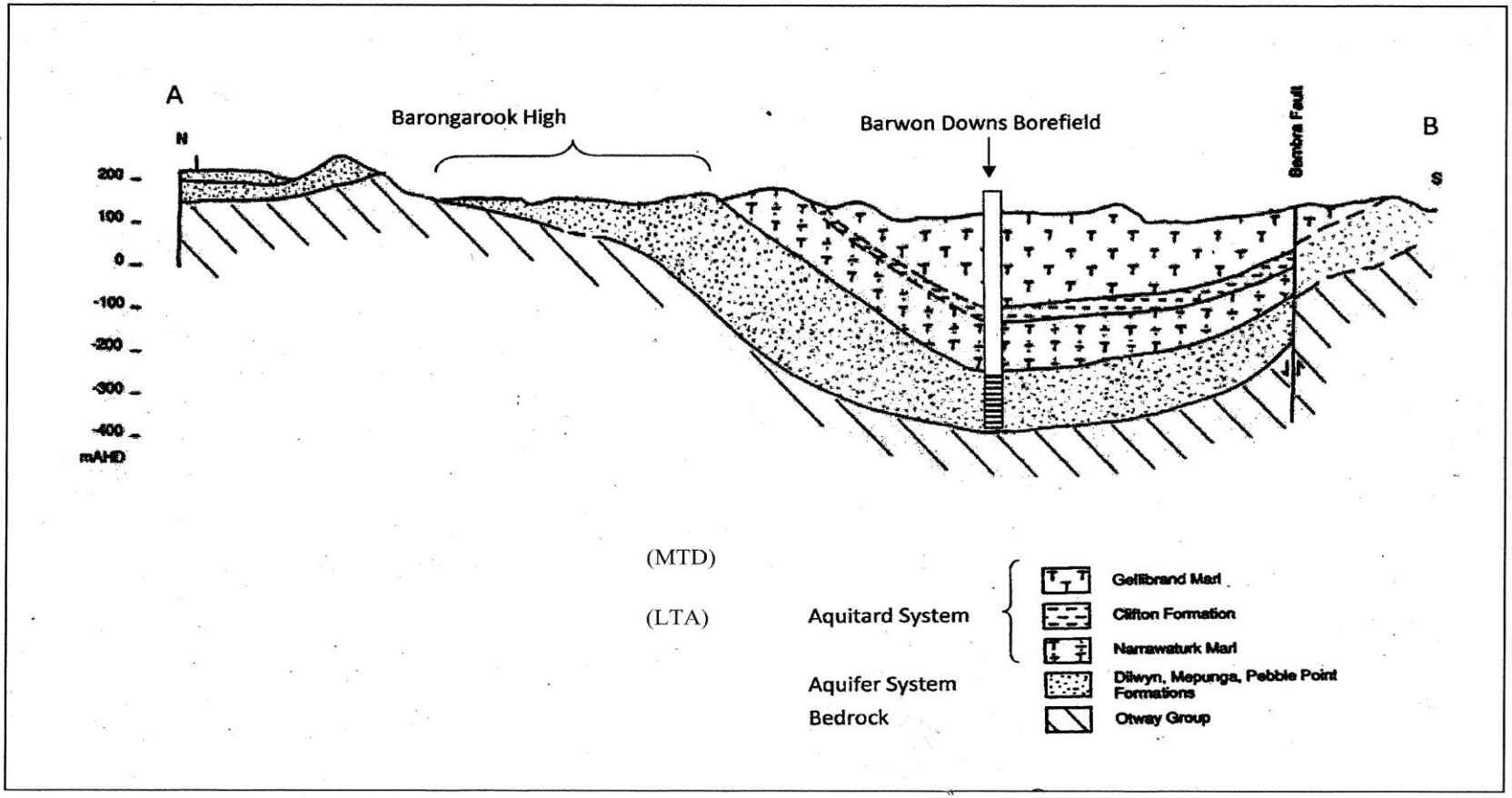
Observation bore name and number	Same bore but different Victorian Water observation bore number	Aquifer formation this bore is drilled into
Yeo 19	110910	Pebble Point
Yeo 20	109111	Dilwyn
Yeo 21	109112	Mepunga
Yeo 17	109108	Dilwyn
Yeo 35	Appears to have been decommissioned mid 1990s	
Yeo 36	Appears to have been decommissioned mid 1990s	
Yeo 37	109128	Dilwyn
Yeo 38	109129	Dilwyn
Yeo 40	109131	Dilwyn
BK 69	48001	Pebble Point



SOURCE: Leonard[24])

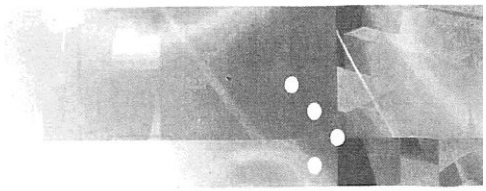
Gerangamete13 is one of the extraction bores many metres deep at the Barwon Downs Borefield. The Mepunga, Dilwyn, Pember Mudstone and the Pebble Point formations make up the LTA shown surfacing as the blue areas marked on the map on page 51.

Figure 4 Geological cross section A-B (modified after Witebski *et al*, 1991) –location of section is on Figure 5



SINCLAIR KNIGHT MERZ

M:\group\ap\WaterResources\Barwon Downs\BARWON DOWNS FLORA STUDY\Deliverables\Final\r01mwd_bd_hydrogeolgy6_BW.doc PAGE 17



SINCLAIR KNIGHT MERZ

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40|020|0023N (1)

Barwon Water
PO BOX 659
Geelong 3220

9 January, 2003
L01GPH_Flora_Assmt
WC01986.100

Attention: [redacted]

Dear [redacted] and [redacted]

Boundary Creek vegetation Surveys
Relationship to Groundwater Levels

Further to your request to provide information on groundwater level responses in the Boundary Creek region, we have collated data from the Groundwater Model and observation bores in the area.

Attached are plots of groundwater level over the recent pumping period and the recovery to date. Observed data was extracted from the GMS database. Modelled data was taken from the Barwon Downs Calibration Model, which has been extended into the recovery period to enable groundwater level comparisons to be made.

Data is presented for cells the are closest to the quadrat sites, in the case of modelled data. For observed data the nearest available bores with recent record have been used.

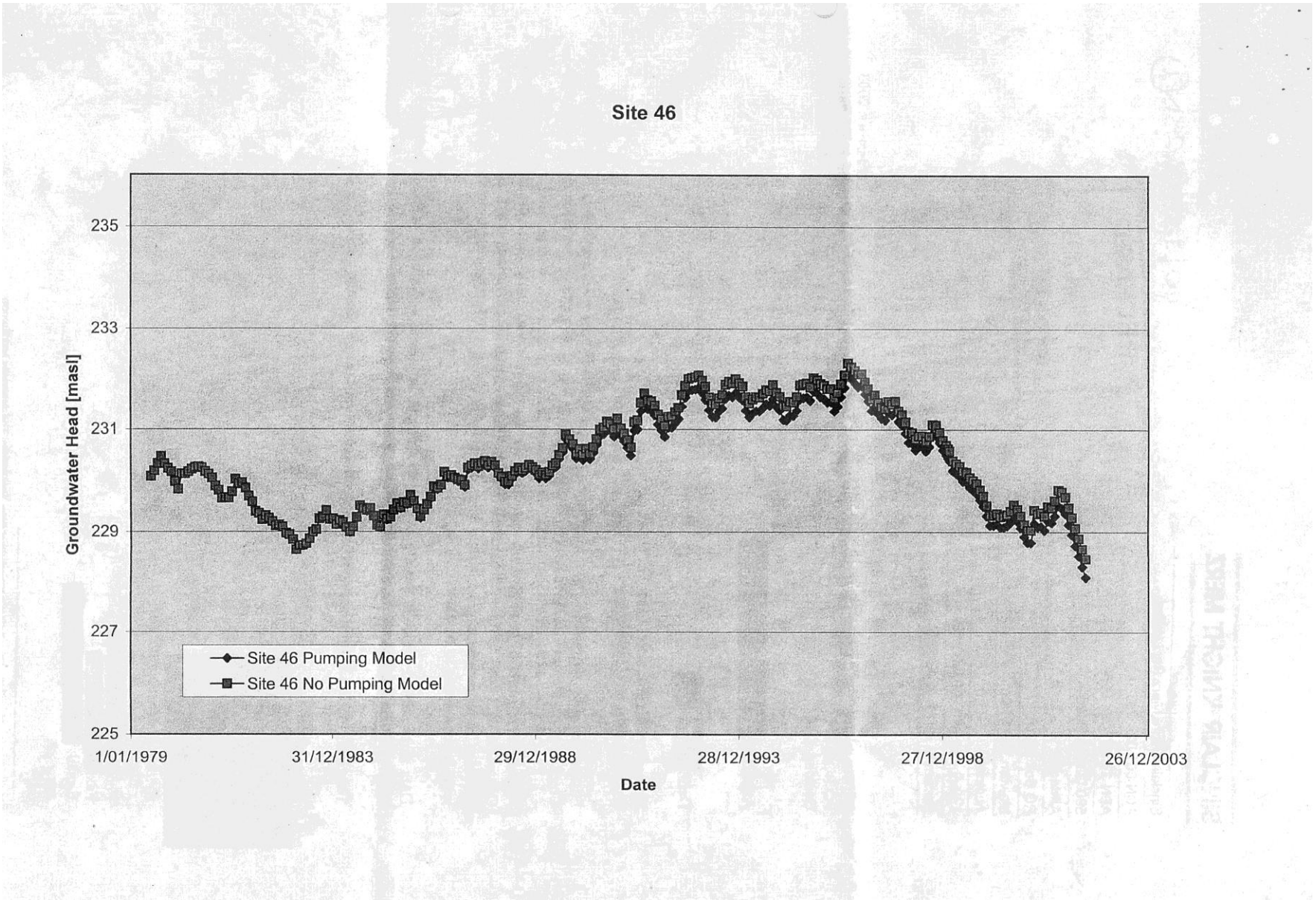
This information is for discussion at our technical meeting on 9th January 2003.

Yours sincerely

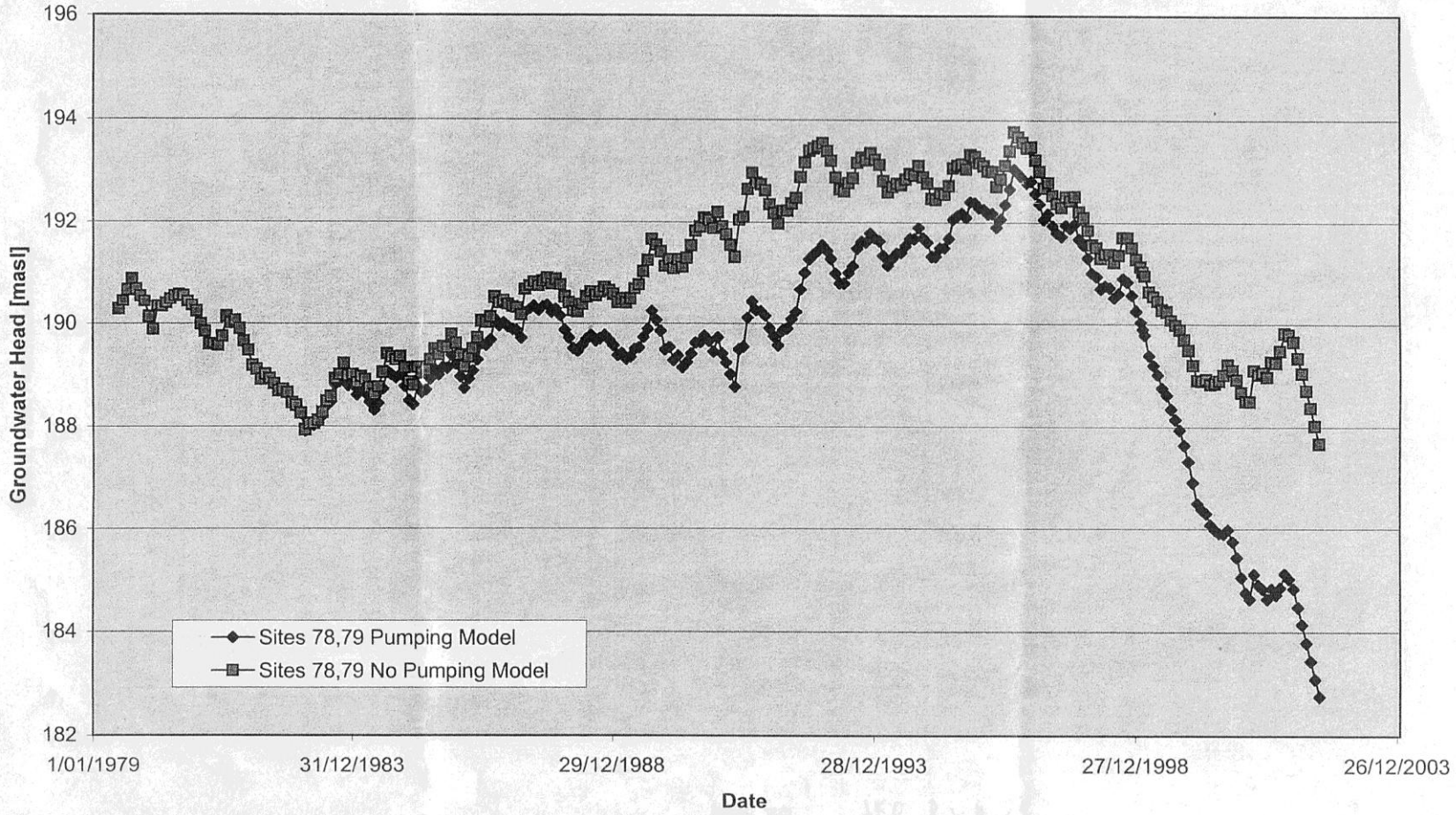
[redacted]

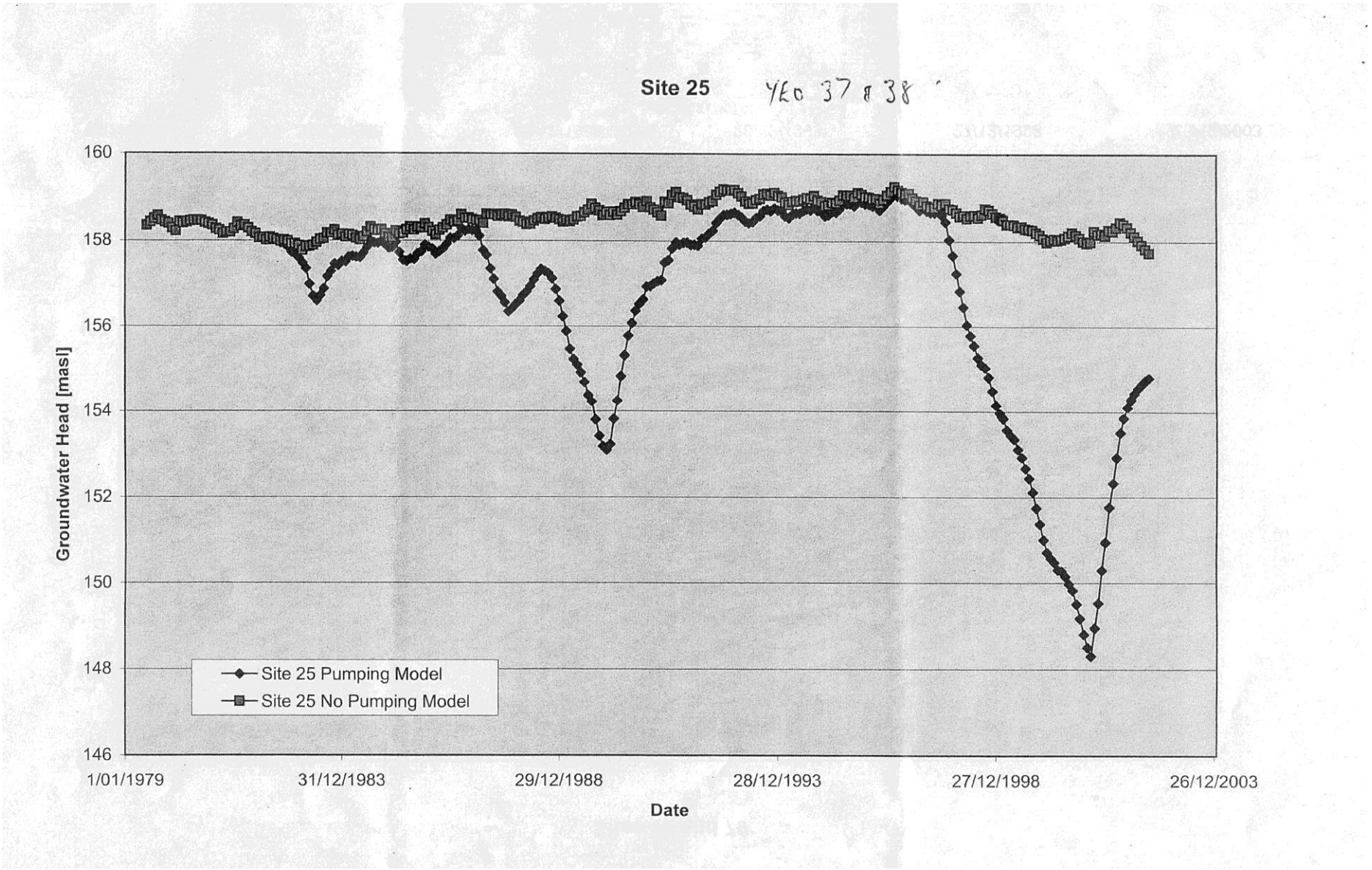
Principal Hydrogeologist

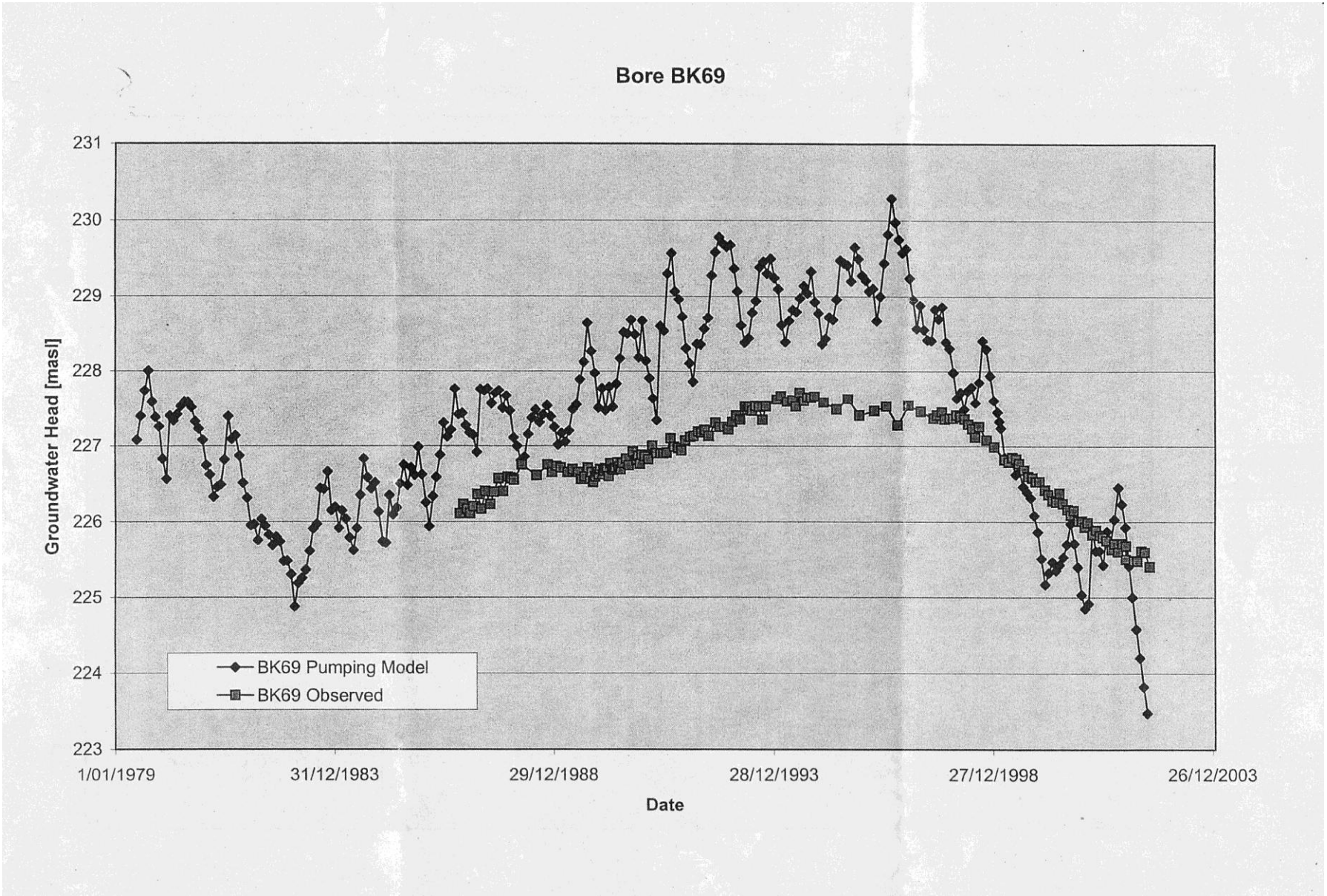
Phone: [redacted]
Fax: [redacted]
E-mail: [redacted]
enc.


Site 46
Groundwater Head [masl]
235
233
231
229
227
225
1/01/1979
31/12/1983
29/12/1988
28/12/1993
27/12/1998
26/12/2003
Date
Site 46 Pumping Model
Site 46 No Pumping Model

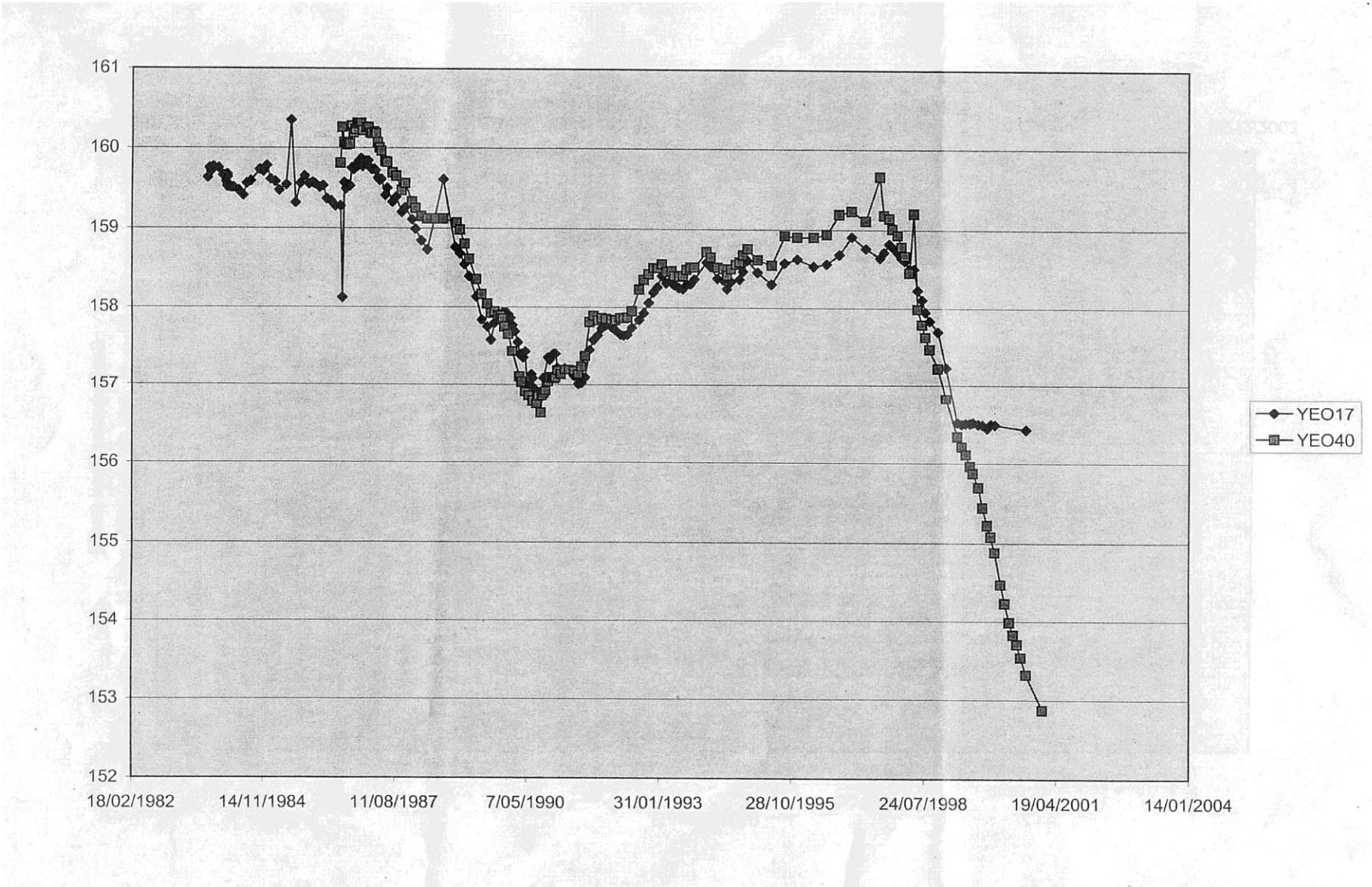
H

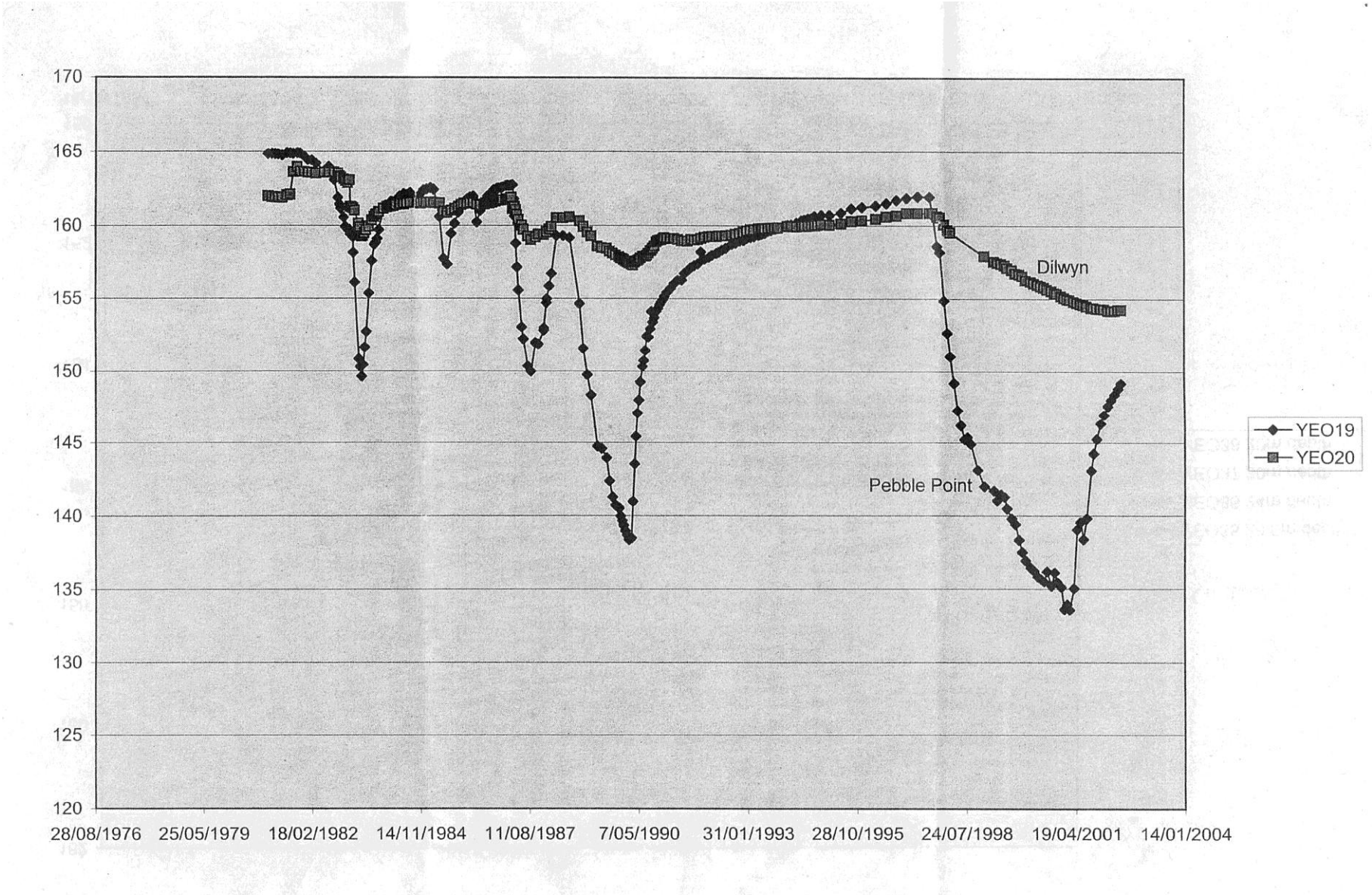

Sites 78 and 79
Groundwater Head [masl]
196
194
192
190
188
186
184
182
1/01/1979
31/12/1983
29/12/1988
28/12/1993
27/12/1998
26/12/2003
Date
Sites 78,79 Pumping Model
Sites 78,79 No Pumping Model

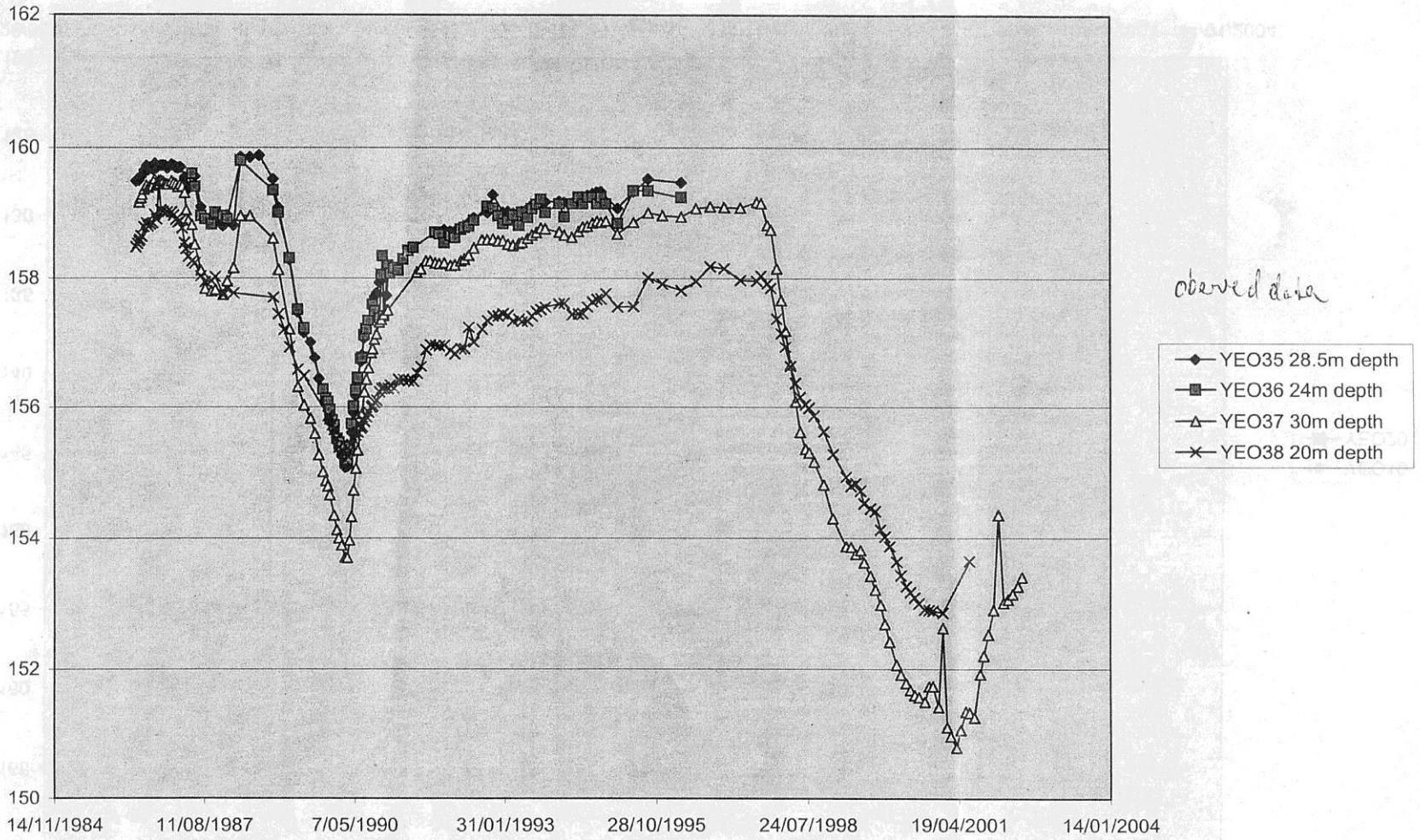

Site 25
Yeo 37 & 38
160
158
156
154
152
150
148
146
Groundwater Head [masl]
Site 25 Pumping Model
Site 25 No Pumping Model
1/01/1979
31/12/1983
29/12/1988
28/12/1993
27/12/1998
26/12/2003
Date

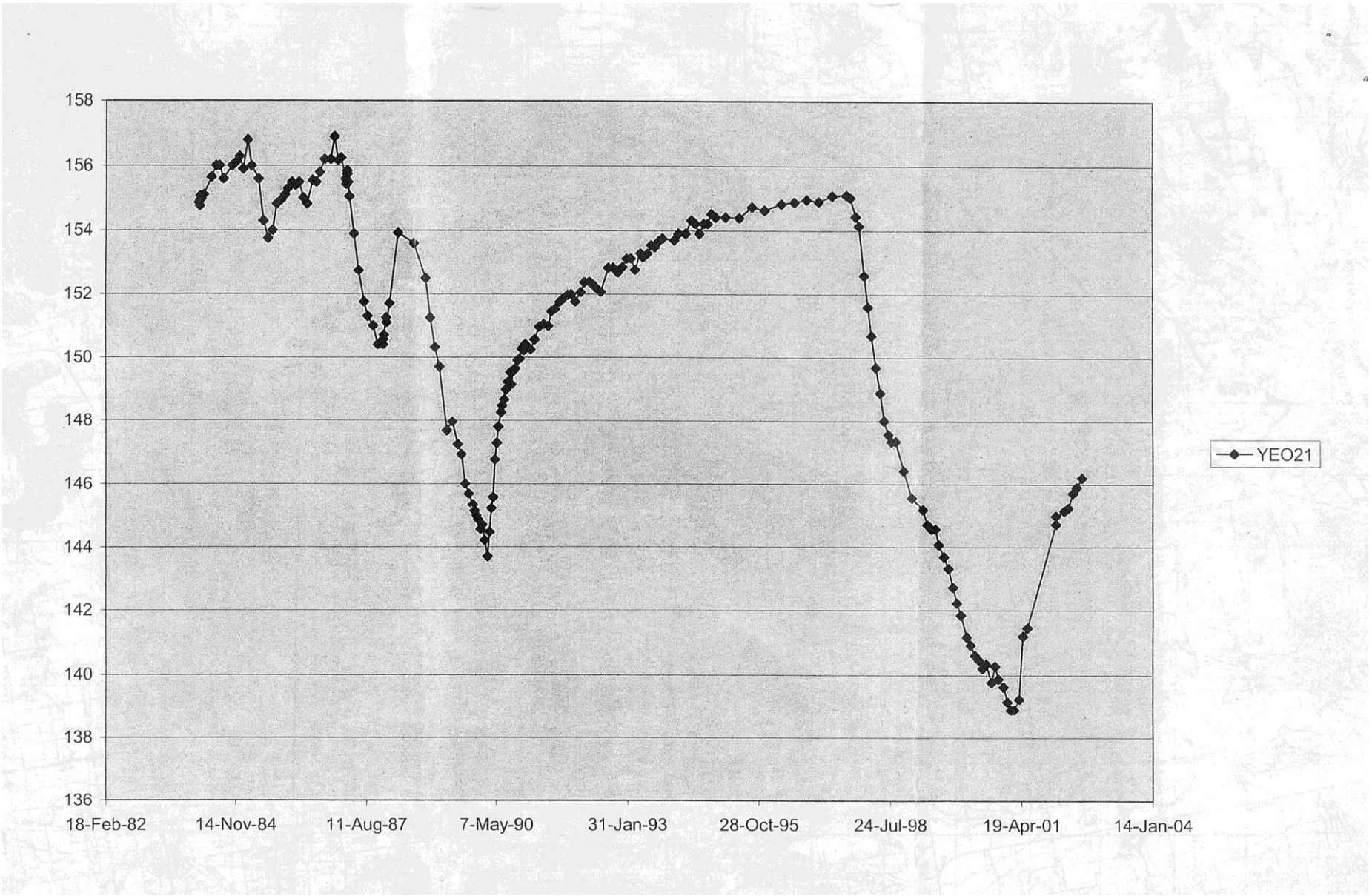

Bore BK69
Groundwater Head [masl]
231
230
229
228
227
226
225
224
223
1/01/1979
31/12/1983
29/12/1988
28/12/1993
27/12/1998
26/12/2003
Date
BK69 Pumping Model
BK69 Observed

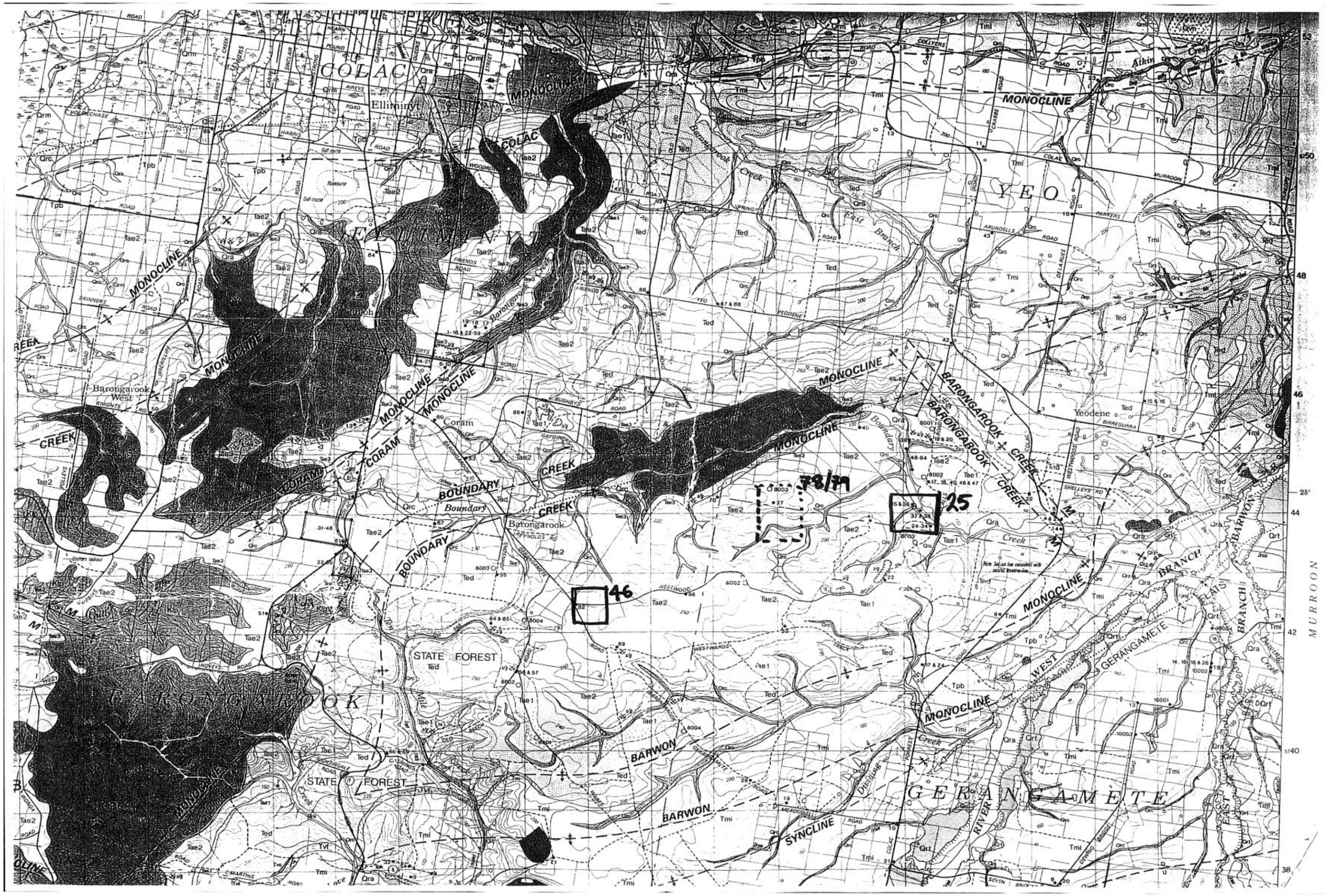
H


161
160
159
158
157
156
155
154
153
152
18/02/1982
14/11/1984
11/08/1987
7/05/1990
31/01/1993
28/10/1995
24/07/1998
19/04/2001
14/01/2004
YEO17
YEO40


170
165
160
155
150
145
140
135
130
125
120
28/08/1976
25/05/1979
18/02/1982
14/11/1984
11/08/1987
7/05/1990
31/01/1993
28/10/1995
24/07/1998
19/04/2001
14/01/2004
Dilwyn
Pebble Point
YEO19
YEO20


162
160
158
156
154
152
150
14/11/1984
11/08/1987
7/05/1990
31/01/1993
28/10/1995
24/07/1998
19/04/2001
14/01/2004
observed data
YEO35 28.5m depth
YEO36 24m depth
YEO37 30m depth
YEO38 20m depth


158
156
154
152
150
148
146
144
142
140
138
136
18-Feb-82
14-Nov-84
11-Aug-87
7-May-90
31-Jan-93
28-Oct-95
24-Jul-98
19-Apr-01
14-Jan-04
YEO21



COLAC
Elliminyt
MONOCLINE
YEO
Yeodene
BARONGAROOK CREEK
Barongarook West
CORAM
Coram
BOUNDARY CREEK
Barongarook
78/79
25
46
STATE FOREST
BARONGAROOK
BARWON
SYNCLINE
WEST GERANGAMETE
GERANGAMETE
MURROON

APPENDIX FOUR

These pages[30] were obtained under Freedom OF Information from Barwon Water (Barwon Water Ref: F073478)

[redacted]

I have plotted these points on the potentiometric contour map (refer to the attached figure) and can confirm that all sites are approximately 20m above the potentiometric surface for the aquifer. The details are as follows:

Site	Easting	Northing	RL (AHD)	Aquifer Head (mAHD)
Flora Site 46	729160.8	5742236.3	242.5	221
Flora Site 78	731978.0	5743325.9	202.5	180
Flora Site 79	732150.6	5743294.3	202.4	177

I think this is clear evidence that the sites are perched above the aquifer and are being fed by local surface waters.

Regards

[redacted]

[redacted] wrote:

> [redacted]
>
> As per my phone message, please find attached water levels for the 3 flora
> sites for comparison with the regional groundwater levels.
>
> Regards
>
> [redacted]
> ----- Forwarded by [redacted] on 05/06/2003 03:27 PM -----
> [redacted] 05/06/2003 11:10 AM
>
> To: [redacted]
> cc:
> Subject: Gerangamete Groundwater Flora Site Levels
>
>
> [redacted],
>

[redacted] 4/06/2012

> Please find attached the report and data for the Flora Sites 46, 78 & 79
as
> requested.
>
> (See attached file: 7861.doc)
>
> Regards,
>
> [redacted]
>
>
****
****
>
> The information in this e-mail message and any files transmitted with it
> are confidential
> and/or privileged and are intended only for the use of the individual or
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> they are addressed. If you received this message in error please notify
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> For a copy of our Personal Privacy Charter please contact us or visit our
> website
> www.barwonwater.vic.gov.au
>
>
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> Encoding: base64
> Download Status: Not downloaded with message

--
[redacted]

Senior Geohydrologist/Geothermal Reservoir Engineer
Sinclair Knight Merz

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Postal Address:
PO Box 2500
Malvern
VIC 3144

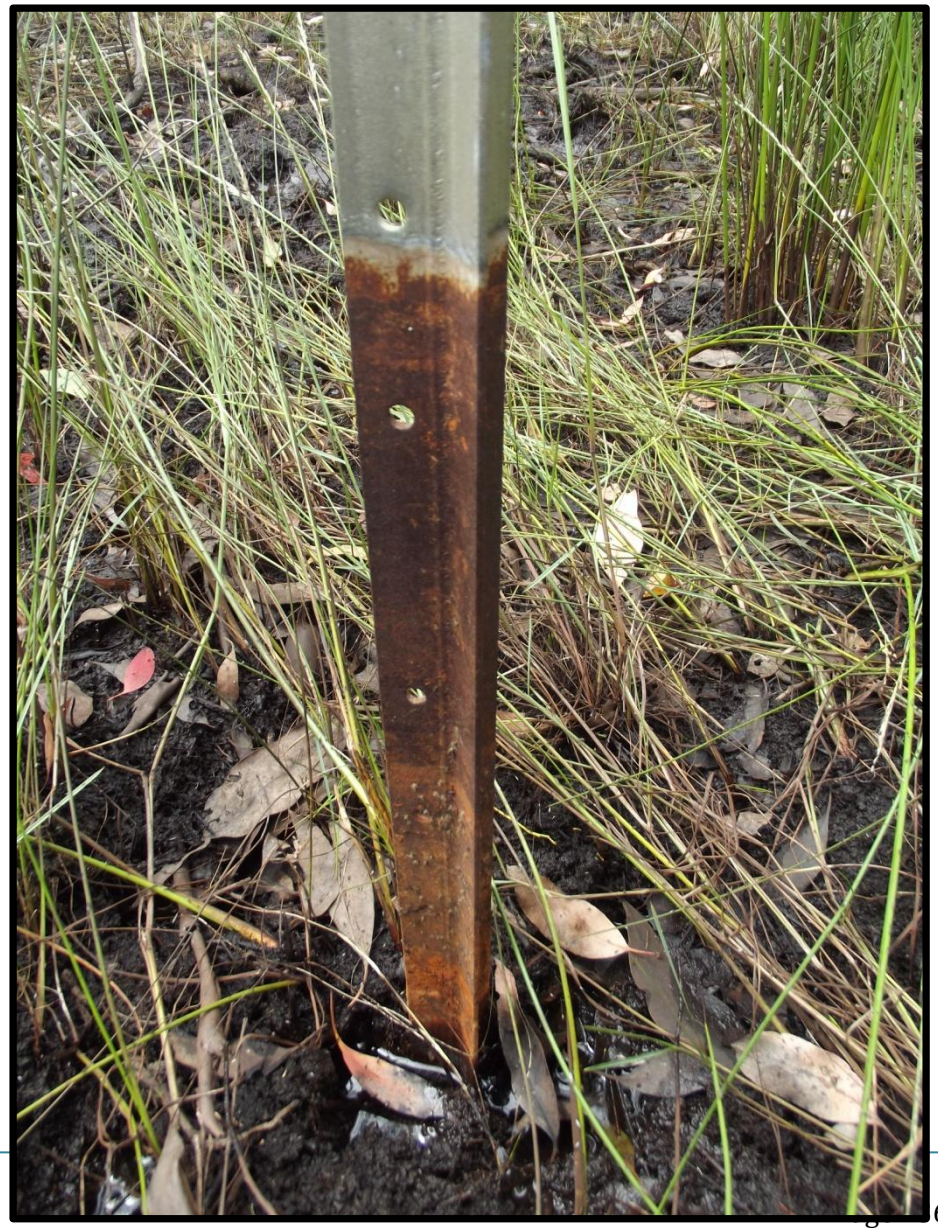
Street Address:
590 Orrong Rd.
Armadale
VIC 3143

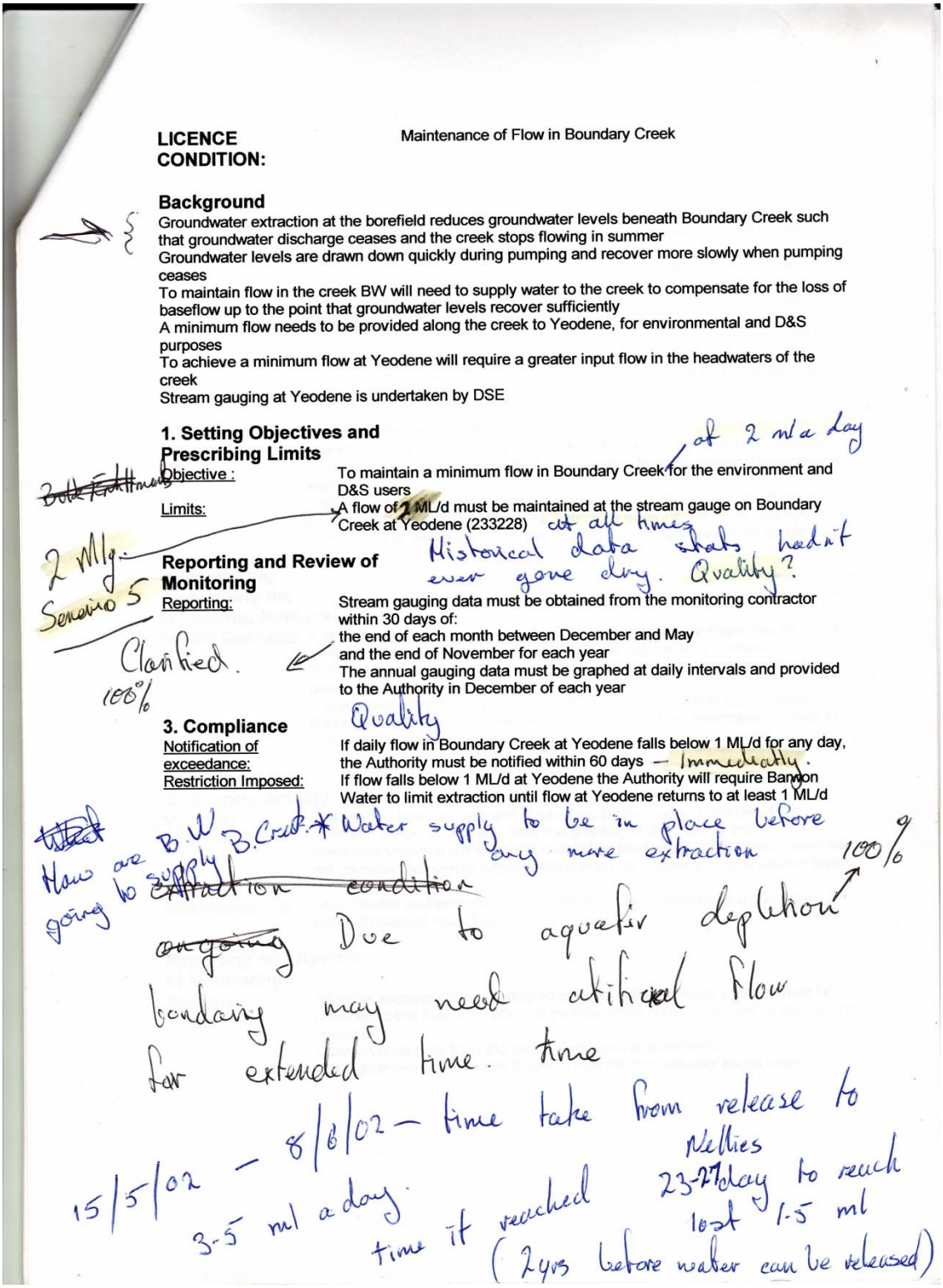
[redacted] 4/06/2012

email: [redacted]
www: htp:\\www.skm.com.au
--

APPENDIX FIVE

These photograps were taken 8 January 2013.





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

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

Limits: A flow of 1 ML/d must be maintained at the stream gauge on Boundary Creek at Yeodene (233228)

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

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

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

APPENDIX SIX

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