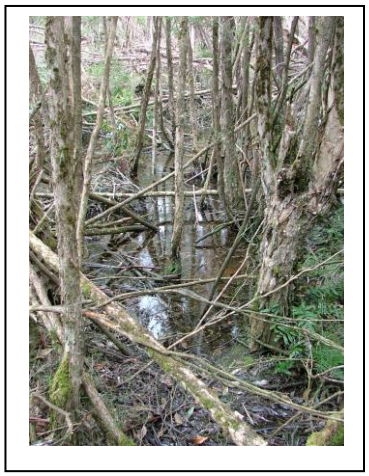
Otway Water Book 31
2017

" Hydrologically Sensitive Vegetation Sites

- Barwon Downs Borefield Area of Influence."



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March 2017

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Timeline of significant events relevant to the Vegetation Studies.

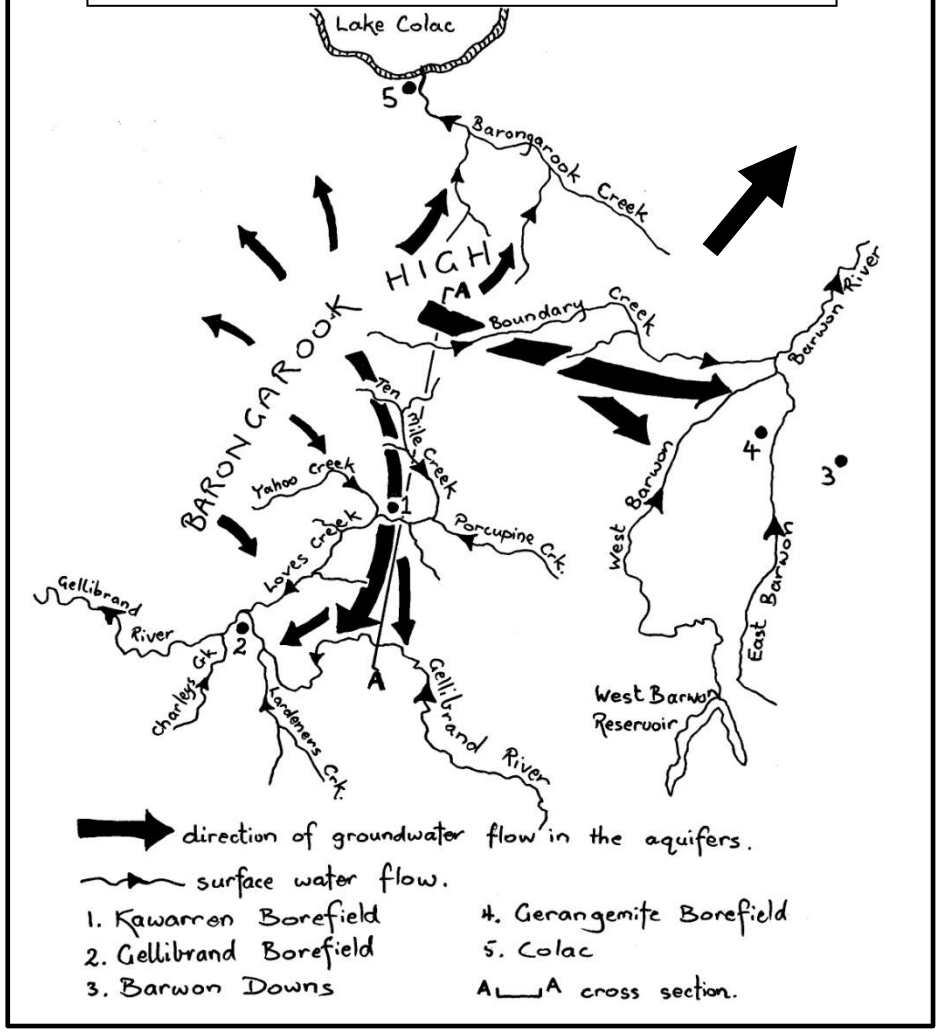
Date	Pages	Event
1970s to 1980s		Geelong's rising water demand prompted a Parliamentary Hearing into water resources in the South-Western District of Victoria.
1982-83		During this drought up to 50% of Geelong City's drinking water was extracted from the Baron Downs Borefield.
1984		Boundary Creek was dry for the first time since the Shalley family bought land adjoining the creek in 1912.
1986		As part of the Parliamentary enquiry Farmar-Bowers completed a preliminary investigation into the possible impacts from groundwater extraction at the Barwon Downs Borefield. He made recommendations to establish baseline data.
1986-91		During 1986-91 a stress test pump was conducted at the Barwon Downs Borefield.
1991		Barwon Water prepared a Service Contract and awarded the flora study component to Ecology Australia.
1992		Ecology Australia completed a very comprehensive report on hydrologically sensitive vegetation sites likely to be impacted from groundwater extraction.
1995		A comprehensive evaluation of the stress test pump made recommendations that included 1500 ML/year extraction that would have little to no impacts; 4000 ML/yr would manifest in some form of impact and anything over 4000 should include refilling/recharging the aquifer during normal to high rainfall periods.
1995		Southern Rural Water granted Barwon Water an extraction licence for 12600 ML/year.
1997		A Permissible Annual Volume that could be extracted from the Barwon Downs Borefield was set at 4000 ML/year. In light of this the 12600 ML/yr licence condition was to be reviewed in 2002 during the licence renewal process.
2002		During the licence renewal proceedings Ecology Australia was asked to conduct a follow up vegetation survey.
2004		Southern Rural Water granted Barwon Water a 20,000 ML/year extraction licence. The licence conditions included 8 vegetation sites that had to be monitored every 5 years for the life of the licence due for renewal June 2019.
2009		The first of the 5 year vegetation investigations was summarised by Barwon Water as inconclusive.
2012		Barwon Water develops a $2.9 million re-vamp of the Barwon Downs monitoring program.
2012		Barwon Water begins to lobby Southern Rural Water to change the vegetation site component of the 2004 licence conditions. The 8 original site are replaced with 14 sites.
2013		The new monitoring program budget is cut back to $1.5 million.
2014-15		The 14 vegetation sites are surveyed and the results used as baseline data from which to make a fresh start.
2016		18 Months later and a follow up vegetation survey concluded that... "***There is no evidence that groundwater extraction from the Barwon Downs borefield has had a negative impact on vegetation activity or condition.***"

The Appendixes to Book 31 are produced as a separate stand alone book.

APPENDIX

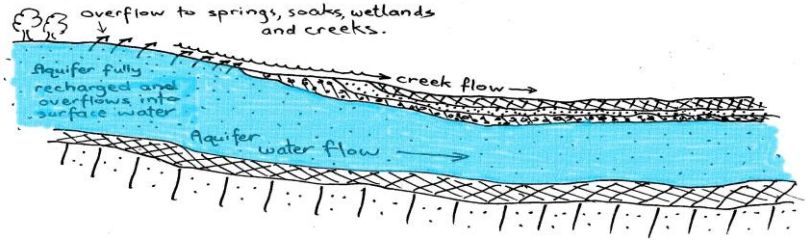
<u>NOTE</u>: In April 2015 Hon Lisa Neville signed off on *Guidelines for Groundwater Licensing and the Protection of High Value Groundwater Dependent Ecosystems* which she defines as "…*those ecosystems that require access to groundwater to meet all or some of their water so as to maintain the communities of plants and animals and ecological processes they support, and ecosystem services they provide.*" F(B43)

Groundwater Flowpaths Emanating from Rain Falling on the Barongarook High Intake Area.

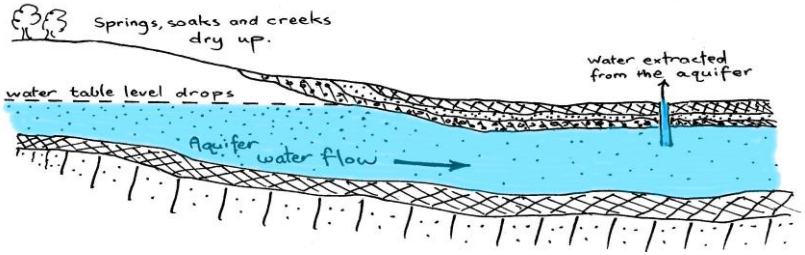


Map Source: John Leonard[70]

The major source of water contributing to these aquifer flowpaths is reported to be rainfall that falls onto the exposed Lower Tertiary Aquifers that surface throughout the Barongarook High.
Under natural conditions the aquifer overflows forming springs, wetlands and flows in perennial creeks and rivers.



Barwon Water extracts huge amounts of water from this aquifer at the Barwon Downs Borefield, point 4 on this map, a major causal factor dropping the watertable levels in the area. Springs dry up, one wetland has been turned into one of Australia's worst acid sulfate soil sites and at least one creek dries up for many months of the year.



This book is dedicated to Charlie Kohout the inaugural President of the LAWROC (Land And Water Resources Otway Catchments) Landcare Group for his wisdom, understanding and never failing advice, and the coffees of course.

NOTE: In April 2015 Hon Lisa Neville signed off on *Guidelines for Groundwater Licensing and the Protection of High Value Groundwater Dependent Ecosystems* which she defines as "…*those ecosystems that require access to groundwater to meet all or some of their water so as to maintain the communities of plants and animals and ecological processes they support, and ecosystem services they provide.*"

INTRODUCTION.

The Barwon Water Authority began serious groundwater extraction from the Gerangamete/Barwon Downs Borefield during the 1982-1983 drought supplying up to 50% of Geelong's water requirements. During the 1986 to 1991 period a stress test pump was undertaken at the Barwon Downs Borefield to determine the implications of extracting large amounts of groundwater from this borefield. The results concluded that 1500 ML/year would see little if any ecosystem environmental impact. However, if 4000 ML/year was to be extracted impacts were to be expected and artificial recharge (ASR) during wet periods was strongly recommended. These findings were finalised in 1995.[116]

In 1995 Barwon Water was granted an extraction licence of 12600 ML/year. Two years later in September 1997 Barwon Water began exercising this right and started extracting water. One month later in October 1997 a Permissible Annual Volume (PAV) of 4000 ML/year extraction from this Borefield was recommended. Southern Rural Water deferred imposing any extraction restrictions in line with the 4000 ML/year PAV until the licence was reviewed in 2002. (see Appendix 16, page **178**).

By 2004 the Permissible Annual Volume had been changed to a Permissible Consumptive Volume and this allowed extractions to be averaged out over many years.[32] In 2004 Southern Rural Water granted Barwon Water a 20 000 ML/year extraction licence that could be averaged out at 4 000 ML over 100 years. The licence comes up for review in 2019. There was no condition stating that there should be any Aquifer Storage and Recovery (ASR) and no ASR has ever been done, officially that is (see page **16** Artificial Supplementary Flows).

To assist the gaining of this 20 000 ML/year extraction licence Barwon Water conducted several studies. The results of these studies helped justifying the granting of the 2004 licence. Flora studies carried out in 1994[93] and 2002[95] made up part of this work. In 2004 the licence conditions stated a follow up flora study was to be completed after every 5 years. The first 5 year study was completed in 2009 and the second completed in 2015.

The first two of these four studies were undertaken by Ecology Australia. The 2008 study was a joint Ecology Australia and SKM venture. This 2008 study was completed as a condition set down in the 2004 extraction licence. In 2014-15, Sinclair Knight Merz (SKM), now called Jacobs, conducted the second five year vegetation study as per the licence conditions. However, in 2012 it was recommended that the vegetation monitoring program should be redesigned making a fresh start (See Appendix 15, page**177**). Ecology Australia has been credited with some involvement in the development and planning of this new work but appear to have been relocated to the "back seat" with no involvement in the actual implementation of the ground work or final report in 2015.[96]

Members of the LAWROC Landcare Group have voiced their displeasure at the disregard given to previous studies and especially the scrapping of data collected by Ecology Australia. These earlier works provide valuable baseline data. Barwon Water, when summarising these early hydrologically sensitive vegetation studies, assert there is no conclusive correlation between impacts on Groundwater Dependent Ecosystems and groundwater extraction at the Barwon Downs Borefield. However, the LAWROC Landcare Group has a contrary view and as a result has commissioned the re-examination of the flora data studies going back to the 1980s.
The following reports are included in this commissioned work, Otway Water Book 31:

1986 Quentin Farmar-Bowers.
1994 Ecology Australia.
2002 Ecology Australia.
2009 Sinclair Knight Merz/Ecology Australia.
2015 Sinclair Knight Merz/Jacobs.
2016 Doug Frood.

This book is an attempt to make much better use of these hydrologically sensitive vegetation studies and in the process determine to what degree they can be used to support the understanding of the connectedness between groundwater dependent ecosystems and the groundwater extraction taking place at the Barwon Downs Borefield.

In the meantime Barwon Water redesigned the hydrologically sensitive vegetation monitoring program making a new start in 2014 and set up 14 new monitoring sites as the benchmark. Previous work has been manipulated in such a way as to be irrelevant to the 2014 benchmarking. Then 18 months later and after resampling these 14 sites, Jacobs concluded that the Barwon Downs Borefield has had no impact on the vegetation in the area of drawdown influence.

(NOTE: The changing of the 2004 groundwater extraction licence conditions involving the 14 new sites is an interesting read, found in Appendix 15, page 137.)

Is it reasonable to set a new reference point starting in 2013?

The 2013 SKM New Monitoring Program, page 66, states... **"***It is difficult to determine impacts of changed groundwater conditions (past or future predictions) when the conceptual understanding of the interaction of terrestrial vegetation and groundwater is poor.*"[88]

...and continues with..."*In part this is the reason why past attempts at Barwon Downs to correlate vegetation condition survey results to groundwater condition have proved inconclusive.*"

There is a very strong case to be put that the evidence and data collected and available in these earlier reports does not support the above assertions and that a new start is not justified. This Otway Water Book 31 presents the case.

The 3 stages making a new start as recommended in the 2013 SKM New Monitoring Report[88] are...
"**Stage 1: GDE location, classification and basic conceptualisation.**
Stage 2: Characterisation of groundwater reliance.
Stage3: Characterisation of ecological response to change."

"*There are key aspects of Stage 1 and Stage 2 assessment that have not been undertaken for potential GDEs in the study area.*" [88]
Once again, as outlined in this book, earlier studies will show this 2013 assertion to also be incorrect.

To say that these stages have not been attempted in the past is extremely misleading. It is quite confounding why the general tenure and thrust of this 2013 SKM New Monitoring Program is to start afresh and begin benchmarking after 2013.

Firstly, it is not correct to state that these three Stages have *not been* undertaken in the past. Earlier investigations and studies clearly covered these three stages. But acceptance of the findings in these reports and the impacts taking place, would have been in direct conflict with the granting and continued extensive use of the borefield.

For example: in the case of the Big Swamp the reality is that this swamp was dependent on year round groundwater discharge sustaining its ecosystems. The swamp had remained unchanged for decades until extensive groundwater extraction took place for urban use. Any conceptual understanding is not required as it has been established that there is a direct connection between the Big Swamp and the Lower Tertiary Aquifers, the aquifers from which the Barwon Downs Borefield extracts its water. Lower the Groundwater Dependent Ecosystem's water source and the site dries up, the Groundwater Dependent Ecosystem (GDE) vegetation dies and is replaced by a drier tolerant species. In the case of the Big

Swamp the drying out process has produced one of the worst Freshwater Upland Actual Acid Sulfate Soil sites in Australia. No "*conceptual understanding*" is required. This is reality.
However, it is understandable why the new monitoring program leading up to the licence renewal of the Barwon Downs Borefield in 2019, has taken the course it has. Barwon Water's intention is to apply for a renewal of this licence and is preparing its case with a positive spin. The ***"...overarching objective of a successful licence renewal..."*** would appear to be the driving force behind all endeavours. It would also appear that this drive is aimed at down playing past history to the exclusion of other considerations detrimental to achieving a licence renewal. Redesigning and benchmarking vegetation studies from 2013 appear to be one such effort.

However, to better understand this and the inappropriateness of the suggestion to bench mark from 2013, one needs to go back as far as 1982.

BACKGROUND leading up to LAWROC's 2016 vegetation study.

1982-1983

During the drought of 1982-83 up to fifty percent of Geelong's water supply came from groundwater extraction at the Barwon Downs Borefield.

1983-86

Barwon Water expressed a need for additional water resources to service the Greater Area of Geelong and it was decided to conduct a stress test pump at the Barwon Downs Borefield in an effort to determine the suitability of tapping into this water resource on a more permanent basis. Before a stress test pump was to be conducted, and in an effort to gain a comprehensive understanding for the appropriate management of the borefield, Quentin Farmar-Bowers was charged with "...***identifying the environmental effects that may occur in the recharge area for the Barwon Downs groundwater project***."[29] After studying rainfall patterns and droughts, Farmar-Bowers[29] suggested that the vegetation on the Barongarook High was able to cope with a substantial degree of rainfall variability, but did say, "***This resilience may greatly delay the response of the vegetation to falling groundwater levels***."
Also...
"***Reduced surface water and lowering of water tables as a result of aquifer pumping would be an additive effect to the natural variability. 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 and would be well beyond that exhibited naturally (L. Barrow, Pers. Com. 1986). Aquifer pumping during droughts, as is proposed, would tend to exacerbate the effect of natural variability by extending the effects of drought***."[29] (L. Barrow being an officer of Barwon Water)

Farmar-Bowers found... "***Lower areas in the topography are influenced by groundwater. Near Boundary Creek water is released from the water table forming springs and waterlogged areas at least during winter and spring. These areas support forms of vegetation that cope with periodically (or constantly) wet conditions. These areas would be affected by a fall in ground water level. In the extreme, the existing vegetation (and animals that use it) would be replaced by other vegetation more able to utilize the new drier conditions. This change may occur quite rapidly perhaps within a few years***."[29]
There is compelling evidence that this change has taken place.

Quentin Farmar-Bowers determined that 1600 ML/year extraction was sustainable. He also made a series of recommendations that should have been conducted. These recommendations included flora or vegetation studies (see Appendix One, page **151**).
At a NREC hearing in the late 1980s Barwon Water stated these studies had been done. None of them were conducted[42] and the opportunity to gather comprehensive comparative data at specific sites was missed. Even though these studies were not conducted as recommended, Farmar-Bowers established the fact that there were Groundwater Dependent Ecosystems that were clearly connected to the Lower Tertiary Aquifers, the aquifer formation the Barwon Downs Borefield extracts its water from.
He also predicted that groundwater pumping could substantially damage the riparian vegetation including swamp vegetation. One of Farmar-Bowers' most interesting predictions is the one where he mentions one form of impact being lower growth, increased insect and pathogen attack. Sixteen years later in the 2002 Ecology Australia vegetation resurvey, these exact symptoms were observable in a scented paperbark forest... "***Observations here strongly suggest that this species is dying out because of predations of invertebrate pests or perhaps a pathogen.***"[95]

1987-1991
The stress test pump went ahead. The findings and determinations and findings from this test were finalised in 1995 and signed off by the Victorian Government of the time. This comprehensive report mentioned 1500 ML/year extraction as sustainable with 4000 ML/year most likely to have noticeable impacts. It was also recommended any extractions over 4000 ML/year to be accompanied with an Aquifer Storage and Recovery process.[116]

SEPTEMBER 1992
Barwon Water, circulated a contract brief[5] titled...

"Inventories and Assessments of the Flora and Fauna Values of the Barwon Downs Aquifer Outcrop Areas and the Streams Draining Them."

The Preamble on page 1 of this brief states... "***It is known that water enters the Barwon Downs aquifer system within the catchments of Boundary and Dividing Creeks and possible the upper reaches of Porcupine Creek.***"[5]

"***Experience with the operation of the wellfield to date has indicated that the streamflow in Boundary Creek has been reduced during the dry period of the year.***"[5]
In fact the creek ceased flowing on numerous occasions.

"***It is anticipated that an Environmental Effects Statement (EES) will be required before approval can be obtained.....***"

"This brief has been prepared to facilitate the gathering of environmental information required for that EES and to identify the need for any ongoing monitoring program."

The Scope of the Work included... "***The Barwon Downs aquifer outcrops within the catchments of these streams and it is in these outcrop areas that the streams receive discharge from the aquifer.***" The connection between wetlands and the aquifer was clearly established. The Brief was designed to assess the possible impacts on these wetland outcropping areas under groundwater extraction regimes.

"***The work required basically comprises the preparation of a report containing maps and inventories of the flora and fauna of the study area with emphasis placed on those species and communities which have a dependence on aquatic environments, together with an assessment of the environmental significance of the species and communities listed.***"

"***Whilst it could be expected that a lowering of the water table will to some degree impact on all flora in the study area, there is a need to identify those areas which are considered more sensitive and may require further monitoring to evaluate response in plant communities to long term changes in the water table.***"[5] These objectives were made in 1992.

This brief also stated ... " ***...the predominant environmental effect to the development of the wellfield will be a lowering of water tables...***"[5]
The following two pages taken from the Contract Brief outline the flora section given to Ecology Australia. The requirements of this contract reflect many of the recommendations made by Farmar-Bowers in 1986 before the stress test extraction. However, by 1992 when this brief was published, over 24 000 ML had been extracted from the borefield.

PART B1
SHEET 1 OF 2

INVENTORIES AND ASSESSMENTS OF THE FLORA AND FAUNA VALUES OF THE BARWON DOWNS AQUIFER OUTCROP AREAS AND THE STREAMS DRAINING THEM

PART B1 FLORA SURVEY

B1.1 OBJECTIVES

To gain an understanding of plant communities in the study area and indentify particular species, communities and areas that are of significance.
The survey is to focus on areas and species that are most sensitive to changes in water table.

B1.2 TASKS

a) Listing of Plant Species occurring in the study area

* Provide a list of species found in study areas.
* Classify plant communities into major groups using dominant species within plant communities.
* Overlay distribution of major plant communities on base map provided.

b) Listing of significant species

* Identify species that are nominated under Flora and Fauna Guarantee Act.
* List plant species and communities that are of botanical significance or classified under "The Victorian Rare or Threatened Plant Database", (DCE).
* Using base map supplied, identify sites that contain significant botanical values, (either individual species or communities).

c) Identification of areas sensitive to changes in the water table

Whilst it could be expected that a lowering of the water table will to some degree impact on all flora in the study area, there is a need to identify those areas which are considered more sensitive and may require further monitoring to evaluate response in plant communities to long term changes in the water table.

* List communities and where possible identify species that are most susceptible to changes in water table.
* Use base map to identify abovementioned areas.

B1.3 METHODOLOGY

a) Survey

Survey will require field work across the entire study area with emphasis being placed on streams and areas subject to inundation.

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PART B1
SHEET 2 OF 2

b) Time frame

Time allocated for completion of Flora component of contract:

* Three weeks (15 days) for collection of data.
* One week (5 days) for preparation of report.

c) Collection of data

In order to include seasonal fluctuations of floral composition the field data should be collected over at least one full year.

Suggested scheduling:

(January) 6 days, collection of resource material, field checking and field survey collecting data.
(April) 3 days, field survey.
(July) 3 days, field survey.
(October) 3 days, field survey.

Surveys using aerial photography interpretation must be field checked.

As the predominant environmental effect of the development of the wellfield will be a lowering of water tables, and consequent reduction of the flow in some streams, the work shall principally address instream communities and the related stream fringes. As a general guide, it is unlikely that deep rooted plants would be affected if the water table is more than 25 metres below ground level, hence emphasis should be placed on areas less than 25 metres above the adjacent stream.

d) Report

* Refer to Part A, Section 6.0.
* Note: Species should be described by scientific names with common name in brackets.

B1.4 COSTING

a) Staffing

Costings should include salaries for two persons to carry out field survey work. Salaries for preliminary desk top collection of data and preparation of final report should be based on one person.

b) Travel and other expenses

Contract amount to include travel expenses and other costs associated with collection of data and preparation of report as specified in Part A.

The flora section of the 1992 brief given to Ecology Australia was concise, explicit and unambiguous.

Prior to the Flora and Fauna Surveys being conducted in the early 1990s.
From 1912 to pre groundwater extraction during the 1982-83 drought, Boundary creek never stopped flowing. However, by 1992 before Ecology Australia conducted its flora work Boundary Creek had 32 no flow days at the Colac Forrest Road Stream Flow Gauging Station.
In 1994 Belcher, who was conducting the fauna research, was under the impression that there had never been any groundwater extraction from the Barwon Downs Borefield prior to his study. He mentioned this in two sections of his report and was not aware that over 20 000 ML had already been extracted from the borefield.

JUNE 1994
In June 1994 Ecology Australia Pty. Ltd. completed a flora report on hydrologically sensitive vegetation for Barwon Water. Eighty one sites or quadrants were surveyed; 1 to 55 and 57 to 82. For some reason there are no records for site 56.
These quadrants covered five streams draining the Yeodene and Porcupine Creek Intake Area.
Namely:

1. The Porcupine East branch from its source to its confluence with Ten Mile Creek (see map page **18**).
2. The West Barwon River from below the West Barwon Dam to its confluence with the East Barwon River.
3. Boundary Creek between the Colac Forrest Road and its confluence with the West Barwon River.
4. Dividing Creek North Branch from its source to the confluence with the West Barwon River .
5. Barongarook Creek between its source and the Old Yeo Road.

The Ecology Australia report states...
"***The study was precipitated by the investigations of Barwon Water into the potential for doubling the capacity of the Barwon Downs groundwater wellfield which would have likely effects on the water table and stream flows in the study area. An inventory and significance assessment of the flora and fauna of the study area was required with an emphasis placed upon aquatic (in-stream, riparian, wetland) environments as well as an identification of vegetation and fauna habitat sensitive to changes in the water table***."

At the completion of the report there was no doubt Ecology Australia had fulfilled the brief as required. Hydrologically sensitive species dependent on high levels of moisture including 44 nationally or regionally significant species were among those plants identified.

"***They may be obligatory aquatic or amphibious, or occur in seasonally wet or waterlogged soils.***"
"***If the watertable of a given site is lowered, minor to profound floristic and structural changes in hydrologically vegetation are inevitable.***"
(This can be seen in the Big Swamp, pages **46-48, 54-58.)**

The1994 report further emphasised that in the normal cycle of climatic fluctuations in rainfall, the "vegetation" is in dynamic interaction with its environment and will alter accordingly. These periods of natural fluctuation include droughts, floods and normal rainfall. An important moderating element affecting this fluctuation is the buffering capacity of a healthy, natural groundwater system.

Once sites of hydrological sensitivity had been established by Ecology Australia it was Barwon Water's responsibility to implement a watertable monitoring program at these groundwater water dependent sites. Other recommendations made by Ecology Australia should have been given due consideration and as time has shown these recommendations should have been implemented but weren't.

Permanent records of the 1994 study were recorded at Ecology Australia Pty Ltd and with the Flora Section, Department of Conservation and Natural Resources, Heidelberg.

None of the recommendations made in Ecology Australia's 1994 report were implemented before the 2002 resurvey took place. *The 1994 recommendations mirrored those made by Quentin Farmar-Bowers in 1986 (see pages **102-103**).*

1997

In 1997 Barwon Water began groundwater pumping as per the extraction licence that had been issued by Southern Rural Water 2 years earlier. The licence allowed for 12,600 ML/year to be extracted. One month later the Permissible Annual Volume for extractions from the Gerangamete Groundwater Management Area was determined to be 4,000 ML/year. However, Southern Rural Water permitted Barwon Water to exercise its 12,600 ML/year extraction licence until the licence was up for renewal in 2002. At this time it was stated that the PAV 4000 ML/year limit would come into force.[101] However, by 2002 the rules had changed and Barwon Water was granted a 20,000 ML/year extraction licence.

1997 and 1998.

The Big Swamp caught fire on two occasions. Historically this swamp had always been inundated, treacherous to enter, and covered in melaleuca squarosa forest. The fire located in the top end of the swamp was coined "Jurassic Park," by the CFA firefighters, because of the wilderness type vegetation. A bulldozer was almost lost in the deep peat and a backhoe working off man made corduroy road, had to be used to gain access to hot spots within the swamp. Some CFA firefighters like to tell the "story" that the bulldozer sank out of site and is still buried in the peat.

May 2002

In 2001 Barwon Water employed Ecology Australia to complete a re-survey of some of the sites surveyed in the 1994 study. A copy of Barwon Water's contract brief has not been seen. However, in the summary section, page one of the re-survey report, it states... "***Ecology Australia was commissioned in 201*** **(It is assumed this was meant to be 2001)** ***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***."

On page 1 the May 2002 report states 24 sites were re-sampled in January and February 2002.

Page One extract from the May 2002 Report...

(iv) Significant differences in floristic (species) composition and structure were detected at several locations: those carrying Pithy Saw-sedge Sedgeland and Fine Twig-sedge Sedgeland (both of which are swamps), and at another site (though not a quadrant site) on Boundary Creek. (It is most likely that this was the Big Swamp location). Vegetation changes at the swamp sites include a decline in some obligate wetland herbs, and invasion by herbaceous and woody species formerly excluded from these very wet environments. The condition of the vegetation at the Boundary Creek site apparently indicates a reduction in available moisture-dependant vegetation.

(v) The observed changes in vegetation composition and structure are clearly the result of decreased moisture availability.....

Once again, permanent records were recorded at Ecology Australia Pty Ltd and with the Flora Section, Department of Conservation and Natural Resources, Heidelberg.

Almost exactly the same recommendations were made as with those made in 1994. None were implemented leading up to the next vegetation survey in 2008 (see pages **102** and **103**.).

Prior to the Release of Artificial Supplementary Flows down Boundary Creek.

As part of the 2004 groundwater extraction licence Artificial Supplementary Flows had to be released into Boundary Creek when flows dropped below one ML/day at the Colac Forrest Road Bridge Stream Flow Gauging Station (see Map, page **26**). As a result of groundwater extraction, days of no flow in Boundary Creek started with a modest few in the early period of extraction to extended periods e.g. 134 days in 2000 and 110 in 2001.[45] However, it has been found that these releases never pass the Big Swamp during extended dry periods. The water soaks into the depleted aquifer at the Big Swamp before it reaches the Colac to Forrest Road Stream Flow Gauging Station.[32] Pumping ceased in 2010 for 5 years. Then in 2016 April to September 3,267 ML was extraction.

2004.
Southern Rural Water issued Barwon Water with an extraction licence for 20,000 ML/year (see Appendix 14, page **170**). The drawdown cone of depression dropped to -60 metres before extraction was postponed in August 2010. Artesian bores stopped squirting metres into the air and the days of no flow in Boundary Creek substantially increased.

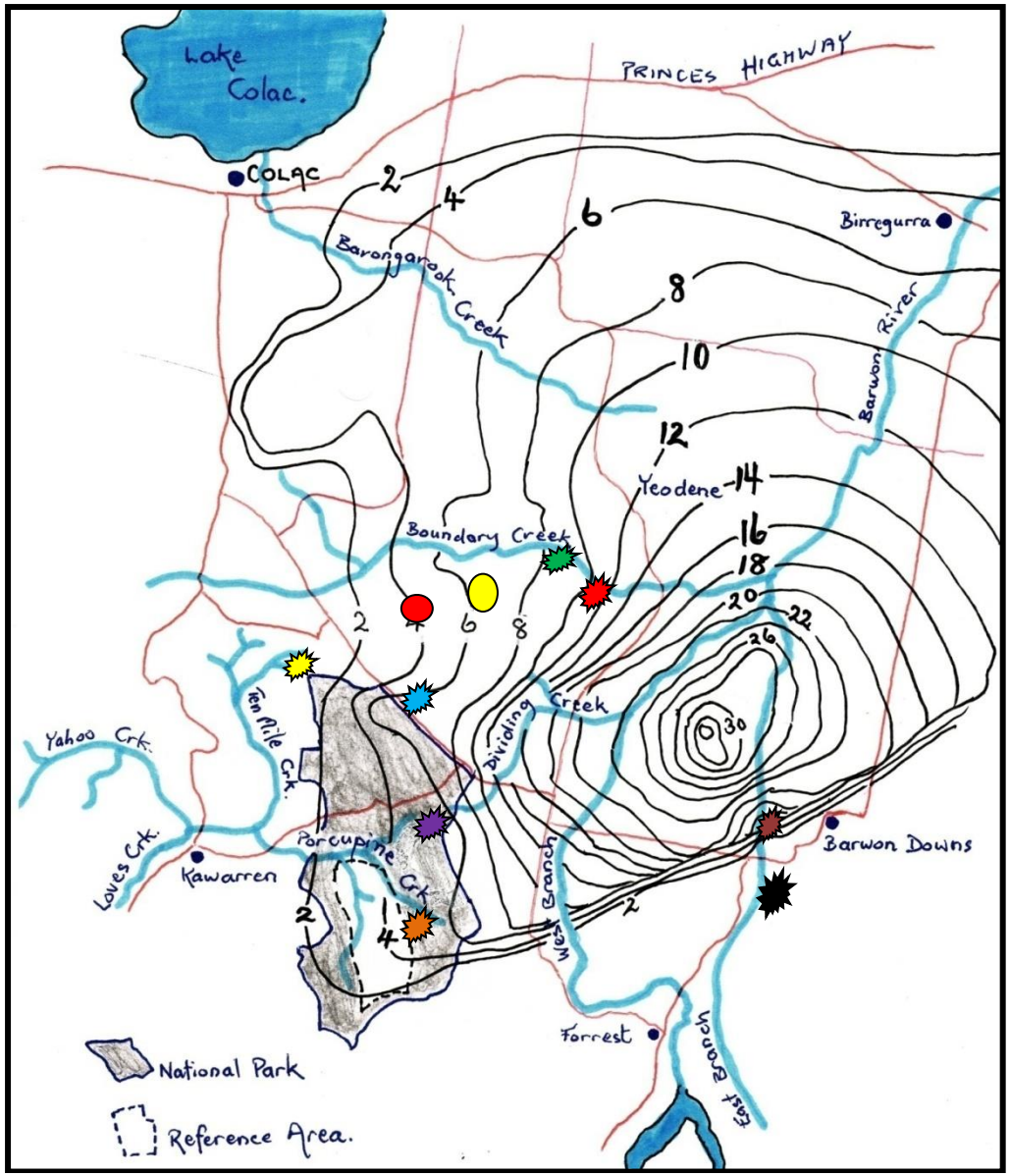
2006 – 2010 Millennium drought
Up to 70% of Geelong City's drinking water supply came from groundwater extraction at the Barwon Downs Borefield during this drought. By the time this drought came to an end over 120,000 million litres had been extracted.

April 2009
In 2008 Sinclair Knight Merz (SKM) conducted the first five year flora study as per a condition of the 2004 extraction licence (see Appendix 14). Once again Ecology Australia was involved in this work, but this time under the direction of SKM.[94]

The licence set out eight sites to be investigated. Three "old" sites from 1994 & 2002 were to be revisited – Sites **25**, **58** and **22**. However, these sites were renamed heralding the start of much confusion that followed with sites being moved, not found, renamed and or incorrectly identified and plotted.

Old Site **25** renamed in 2008 as Site **1** (or 7.1a),
Old Site **58** renamed in 2008 as Site **2** (or 7.1b) and
Old Site **22** renamed in 2008 as Site **6** (or 7.1c).

New 2008 Sites 3, 4, 5, and site 6 (site 6 previously called Site **22**) were stated as control sites. However, all of the eight sites in this 2008 vegetation study, including the control sites, fell well inside the area of drawdown influence from the Barwon Downs Borefield. Scientifically speaking none of these sites could be classed as a control site. The discussion on pages **39** to **40** regarding 2008 Site 6 (Site **22** in 1994 and 2002), highlights why this was an extremely poor decision to choose sites within the drawdown area of influence as control sites. The licence regulator, Southern Rural Water, should have detected this when scrutinising the licence application. Just one of many such occurrences to follow.



Map One.
SOURCE: Barwon Water 2000s Licence Renewal Process handout.
Contour lines show amount of aquifer drawdown.

This map has the 2008 survey sites superimposed.

Site 1 in 2008 (1994 Site 25).

Site 2 in 2008 (1994/2002 Site 58).

Site 3 New site on Ten Mile Tributary.

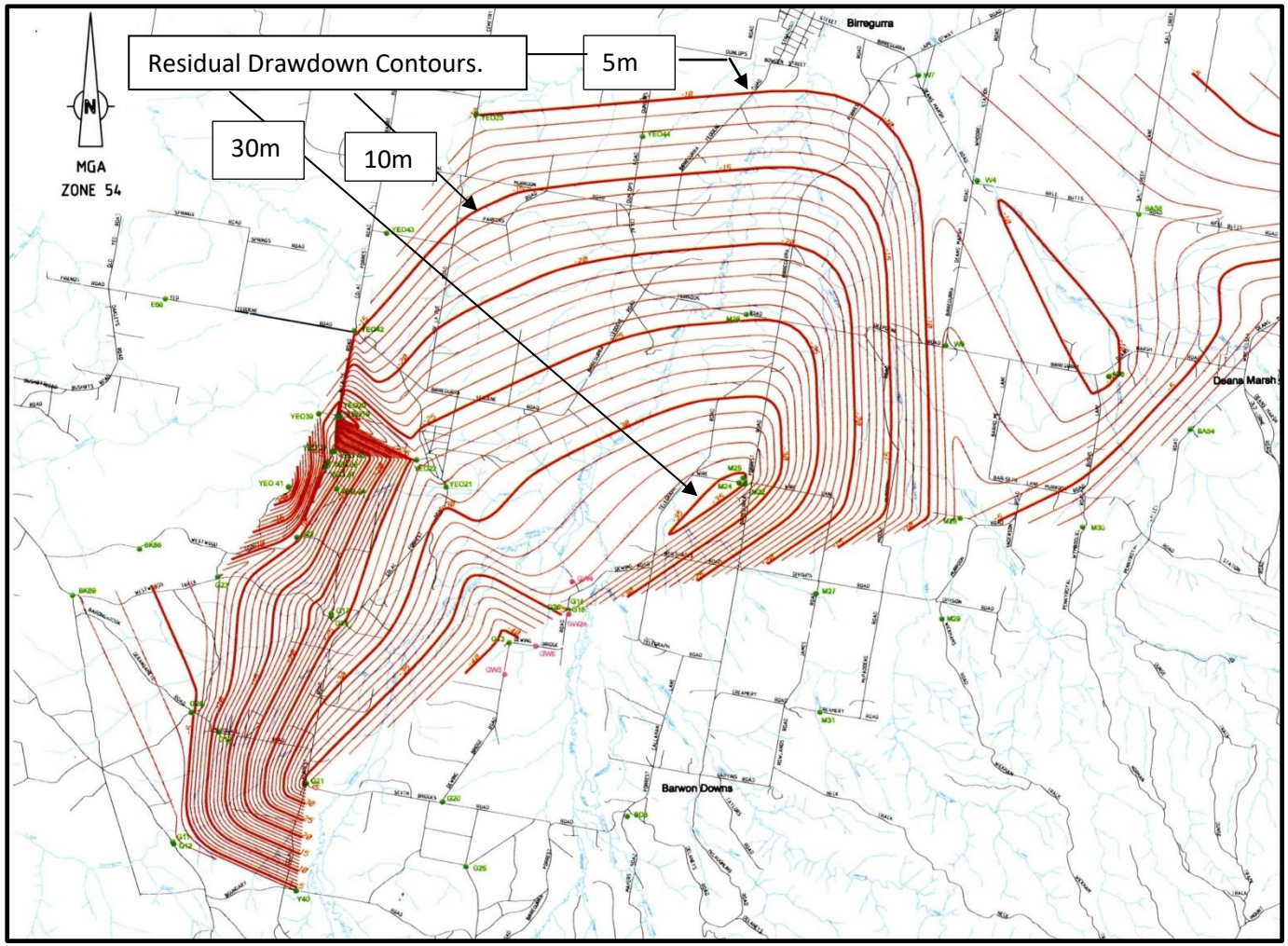
Site 4 in 2008.

Site 5 in 2008.

Site 6 in 2008 (1994/2004 Site 22).

Site 7 in 2008. **Site T5 in 2015.**

Site 8 in 2008. **Site T6 in 2015.**



Map Two
Source: Barwon Water. Residual Drawdown Map for 2008.

Steel droppers were driven into the sites visited during the 2008 vegetation survey. This type of site identification was one of the recommendations made back in 1994. Droppers were driven into other sites visited but the results and findings of these additional sites visited were not recorded in the 2008-09 report.

Once again the recommendations made in this report mirrored the ones made in 1986, 1994 and 2002.

2010

As the water table continued to be lowered the impact moved further downstream in the Big Swamp creating havoc as it went. The acid and heavy metals killed the melaleuca forest and ecosystem as it went. The swamp changed from a carbon positive to a carbon negative site. The dead and dying vegetation fell upon itself creating a massive fuel- load. In 2010 the Big Swamp was on fire again as a result of spontaneously combusted or from smouldering underground for the previous 12 years.

The fire escaped from the Big Swamp creating a wildfire of some proportion (see the fire map, page **55**). The peat swamp continued to burn and show underground hot spots for many months. No assurance can be given that the underground smouldering has ceased.[39][48][49] The entire swamp was engulfed in fire.

2012

"In 2012 it was recommended that a comprehensive flora monitoring regime be established to better understand the relationship between groundwater extraction and potential impacts to groundwater dependent vegetation" (Jacobs 2015 Barwon Downs Vegetation Monitoring Report[96]). This recommendation was first made in 1986 and the 1994 flora survey was conducted with this very same objective in mind. Who made this 2012 recommendation to start again has never been disclosed but it is significant that this statement appeared to have been made with complete disregard to earlier studies. Local community involvement was not sought and as a result there appeared to be no voice arguing the case that earlier data and studies should be included in the 2013-14 proposed work.
In 2014 Southern Rural Water agreed to Barwon Water implementing this changed vegetation monitoring regime allowing the extraction licence conditions to be modified (see Appendix 15, page **177** for the new licence conditions).

The Second Five Year Vegetation Study was Concluded and Reported on 7 July 2015.

During 2014-15 SKM/Jacobs conducted a second vegetation survey as per the conditions of the modified groundwater extraction licence. Sadly previous vegetation studies were largely ignored when developing this latest vegetation mapping and hydrologically sensitive vegetation sites program. The 2015 effort included 14 "new" sites. An observation bore was sunk in close proximity to each of these sites if not already present. The implementation, relating observation bore monitoring with water sensitive vegetation monitoring, comes 30 years after it was first recommended; and after one hundred and twenty thousand million litres have been extracted from the borefield. The 2015 vegetation monitoring report states that 3 of the 14 sites are in the vicinity of previously assessed flora sites. However, they are also stated as not comparable. The remaining 11 sites are cited as being completely new sites that had not been previously assessed.

After cross referencing and scrutiny of previous reports it is believed that six 2015 sites, T2, T3, T7, T8, T11 and T12, are in close proximity, if not the same sites, to previously monitored sites. Also, one additional site, T1 at the Big Swamp, has most definitely been visited in the past though not directly referred to in any previous Barwon Water report. Sadly Barwon Water continues to avoid any meaningful study of the Big Swamp. Then 18 months later in 2016 these 14 "new" sites were revisited and another report written. The 2016 conclusion being that the Barwon Downs Borefield has had no impact on water sensitive vegetation sites. This may be the case between 2014 and 2016 but it is not true if the period 1984 to 2016 is examined. A totally different picture emerges.

Was a New 2013 Monitoring Program Necessary?

In 2013 Barwon Water convinced Southern Rural Water that a new vegetation study start was required by stating that **none** of the following 3 stages in regard to hydrologically sensitive sites had been implemented to any degree of certainty...

"**Stage 1: GDE location, classification and basic conceptualisation.**
Stage 2: Characterisation of groundwater reliance.
Stage 3: Characterisation of ecological response to change."

"***It is difficult to determine impacts of changed groundwater conditions (past or future predictions) when the conceptual understanding of the interaction of terrestrial vegetation and groundwater is poor.***"[7]

...and... "***In part this is the reason why past attempts at Barwon Downs to correlate vegetation condition survey results to groundwater condition have proved inconclusive.***" [7]

Is there any Justification for this suggestion of a New Start in 2013?

The answer to this question can best be found when relating each of these stages to earlier studies.

Stage 1: GDE location, classification and basic conceptualisation.

Farmar-Bowers' work in 1986, enunciated a basic conceptualisation that appears to have stood the test of time. He identified the need for environmental studies, gave reason why they should be conducted and made some very perceptive predictions on outcomes most likely to occur if groundwater extraction at the Barwon Downs Borefield was to proceed.[29]

The brief given to Ecology Australia in 1992[5] clearly and specifically stated what was required: the location, classification and conceptualisation of hydrologically sensitive vegetation in the Barwon Downs Borefield impact area. The 1994 Ecology Australia[93] report clearly assessed, surveyed and mapped the aquifer outcropping areas, associated streams, water sensitive vegetation sites and categorised their botanical significance. It was then Barwon Water's task to collect and analyse data to establish the degree of connection between groundwater drawdown from borefield extraction and any vegetation impacts. This follow up work would have been invaluable, validating basic conceptualisation.

These 1986 and 1994 works had in fact already covered the criteria as outlined in the 2013 **Stage 1** program.

Stage 2: Characterisation of groundwater reliance.

In 1994 Ecology Australia reported that... "***Hydrological sensitive species and vegetation communities are identified and anticipated impacts from altered hydrology are briefly discussed*.**"[93]

Of the 82 quadrant sites visited 392 vascular plant species were identified. 34% or 134 of these were deemed hydrologically sensitive. 44 were of National or Regional significance. "***These swamp or wetland plants include a range of life forms from small herbs to trees, some of which (e.g. Scented paperbark, Melaleuca squarosa) are vegetation dominants. They may be obligatory aquatic or amphibious, or occur in seasonally wet or waterlogged soils.***"[93] Vegetation groundwater reliance sites were characterised and logged.

The 82 quadrant sites were characterised into 6 categories with detailed descriptions linking the categories to groundwater reliance. This was a comprehensive and detailed report of over 240 pages. Using the findings of this report, Barwon Water successfully gained a water extraction licence for 12,600 ML/year. Unfortunately, any follow up work recommended in this report was also ignored until it was time to think about applying for the renewal of the 2002 licence.

It would appear that the first **two stages** recommended in the 2013 SKM Report's new benchmarking were completed by Ecology Australia in 1994.

In May 2002 Carr of Ecology Australia[95] tabled a follow up report for Barwon Water. Carr targeted 24 of the 1994 hydrologically sensitive vegetation sites.

In the Summary section, this report refers back to the 1994 survey... "***The vegetation was documented to detail its significance and identify vegetation types to be hydrologically "sensitive", that is, potentially affected by water extraction by Barwon Water from the Barwon Downs groundwater wellfield*.**"[95]

The 2002 Carr report continued with... "***Significant differences in vegetation floristic (species) composition and structure were detected at several locations...***"[95]

"***The observed changes in vegetation composition and structure are clearly the result of decreased moisture availability.***"[95]

Stage3: Characterisation of ecological response to change.

Comment on ecological response to change is scattered throughout all of the previous studies referred to above. The Otway Water Books describe in detail many examples of ecological response to change. This book 31 further emphasises the ecological response to change that has taken place.

The above mentioned three stages claimed by SKM not to have been covered have in fact been dealt with in most if not all aspects and cannot be ignored.

Looking at Previous and Most Recent Data, from a Different Perspective to that of SKM/Jacobs.

It is worthwhile examining the following two statements made in the SKM 2015 New Monitoring Program.[96]

"*It is difficult to determine impacts of changed groundwater conditions (past or future predictions) when the conceptual understanding of the interaction of terrestrial vegetation and groundwater is poor.*"

"***In part this is the reason why past attempts at Barwon Downs to correlate vegetation condition survey results to groundwater condition have proved inconclusive.***"

There is little explanation given in the 2015 report explaining what other reasons have contributed to the lack of earlier studies being unable to provide conclusive results. Perhaps it has been Barwon Water's inability to conduct a co-ordinated, consistent and comprehensive set of vegetation studies, AND or, failure to fulfil its part with the compiling and recording of data specifically linked to hydrologically sensitive sites and groundwater drawdown.

The following are indicators that go some way to understanding and help explain how Barwon Water has been able to justify conclusive results can't be reached ...

1. In 1988 at the NREC hearing in Colac, Barwon Water officers stated that the Farmar-Bowers recommendations had been implemented and the necessary data collected when no such thing had been done. Not only does this demonstrates a lack of thoroughness and environmental awareness on Barwon Water's part but also shows how easily an unsubstantiated statement is accepted.
2. Recommendations made in 1986, in 1994, again in 2004 and 2008 were largely ignored (see pages **102** and **103**). If one ignores recommendations aimed at achieving an end then the task of achieving a result becomes more difficult and inconclusive outcomes result.
3. It was not noticed or acted upon that each successive set of recommendations mirrored the preceding report.
4. No attempt was made to link available observation bore, and other data, directly to the hydrologically sensitive sites identified in Carr's vegetation studies.
5. Predictive impacts made in earlier studies were not taken seriously nor were they put to the test.
6. Continuity of hydrologically sensitive sites has been haphazard, confusing and disjointed.
7. Recent reports have been lacking in scientific vigour.

8. Site numbers have changed causing confusion and difficulty correlating data.
9. Some sites have multiple and confusing identification (see pages **116**).
10. Site co-ordinates have been recorded in numerous modalities causing inaccurate resurveying and site identification.
11. Some site co-ordinates have been grossly inaccurate (see page **116**).
12. The method of examining sites was changed when Ecology Australia was dismissed as lead operator.
13. When revisiting an area earlier sites could not be found.
14. One site was "lost" in one survey and then re-found in the next survey.
15. Other sites initially deemed appropriate were relocated nearby, renumbered and regarded as a new site.
16. Control sites were chosen inside the residual drawdown area of influence from the borefield on numerous occasions.
17. Ecology Australia was dismissed as the lead operative disrupting continuity.
18. Local input was largely ignored.

Southern Rural Water's lack of scrutiny and proactive participation was most likely another crucial factor contributing to the lack of any conclusive result and the reason Barwon Water was able to bring about a modification to vegetation monitoring licence conditions so easily in 2012-13.

Late in 2015

Up to this time Barwon Water has insisted there is insufficient data and information to draw any conclusion regarding the impact on vegetation from groundwater extraction at the Barwon Downs Borefield. The following pages discuss why this statement is flawed and how such a stance has come to pass.

2016

In 2016 LAWROC Landcare Group commissioned Doug Frood to conduct vegetation surveys on the following sites. Four sites were chosen in an attempt to have some continuity and comparative analysis of sites identified as groundwater dependent ecosystems in the 1994 Ecology Australia survey. Two additional sites, T1 and Maggios were included.

Sites Chosen for this 2016 survey were:

1994/2002 Site 15, renamed Site T12 in 2015.
1994/2002 Site 22, renamed Site 6 in 2008.
1994/2002 Site 45,
1994/2002 Site 78, renamed Site T3 in 2015.
2015 Site T1 (The Big Swamp), and

2009 Maggios Swamp Wetland.

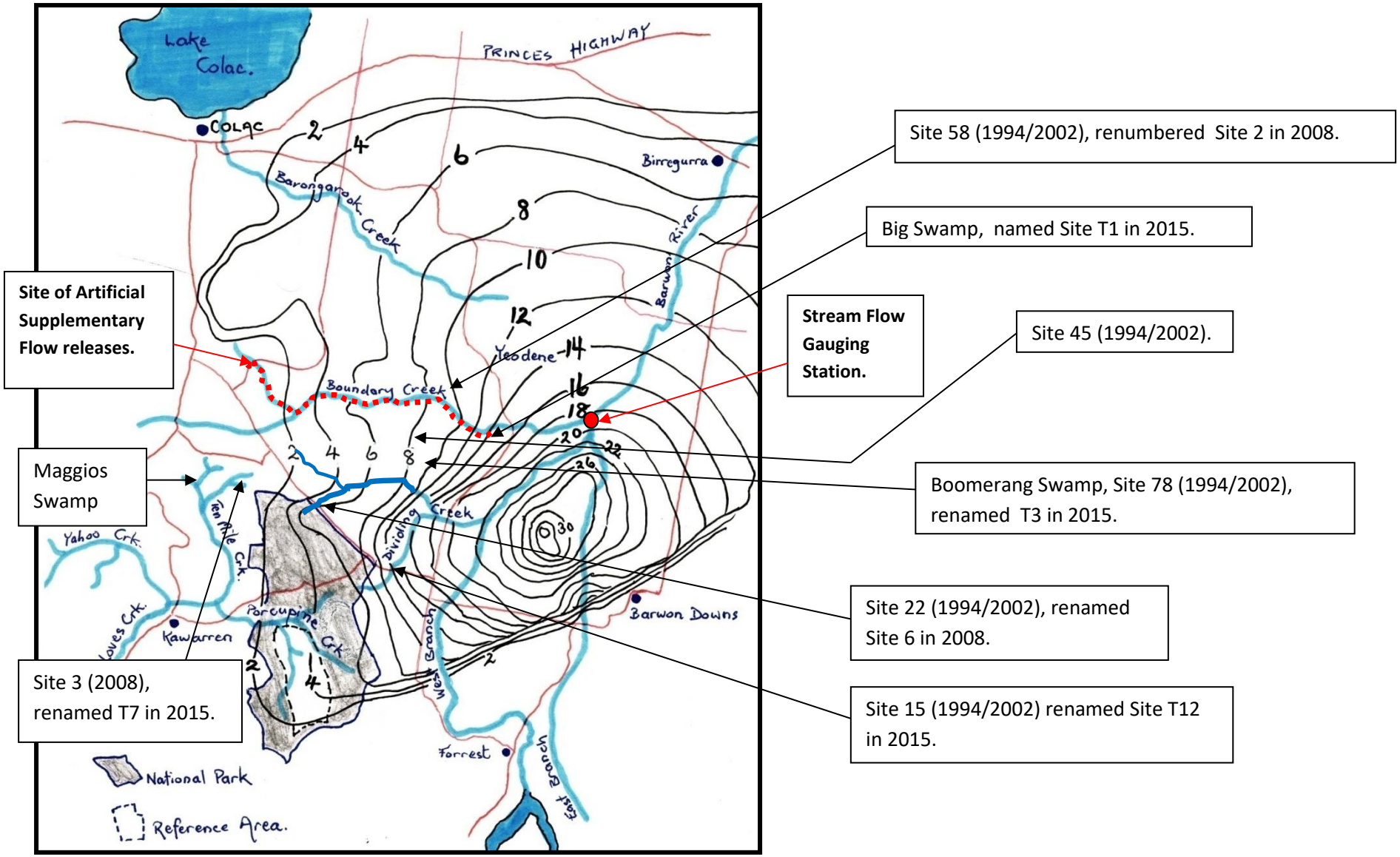
Maggios Swamp Wetland was chosen, even though it was inside the residual drawdown area from groundwater extraction at the Barwon Downs Borefield, as a site that appeared to have had very little change to the vegetation structure in living memory. In 2009 SKM determined that this section of the headwaters of Ten Mile Creek sourced its perennial waters from the Lower Tertiary Aquifers.[90] Consequently this site was, perhaps, as close as one could get to being a control site. In nature its vegetation composition is similar to that originally found in the Big Swamp.

As well as commenting on the Frood report the following sites have also been included, making a total of 9 sites researched in this Otway Water Book 31 for the LAWROC Landcare Group.

1994/2002 Site 58, renamed Site 2 in 2008, and
1994/2008 Site25, renamed in 2015 as Site T2..
2008 Site 3 Ten Mile Creek(2008), renamed T7 in 2015.

All of these nine sites were chosen for very specific reasons, reasons that go a long way to being able to conclusively understand how much groundwater extraction at the Barwon Downs Borefield has had on groundwater dependent ecosystems within the residual drawdown sphere of influence from this borefield.

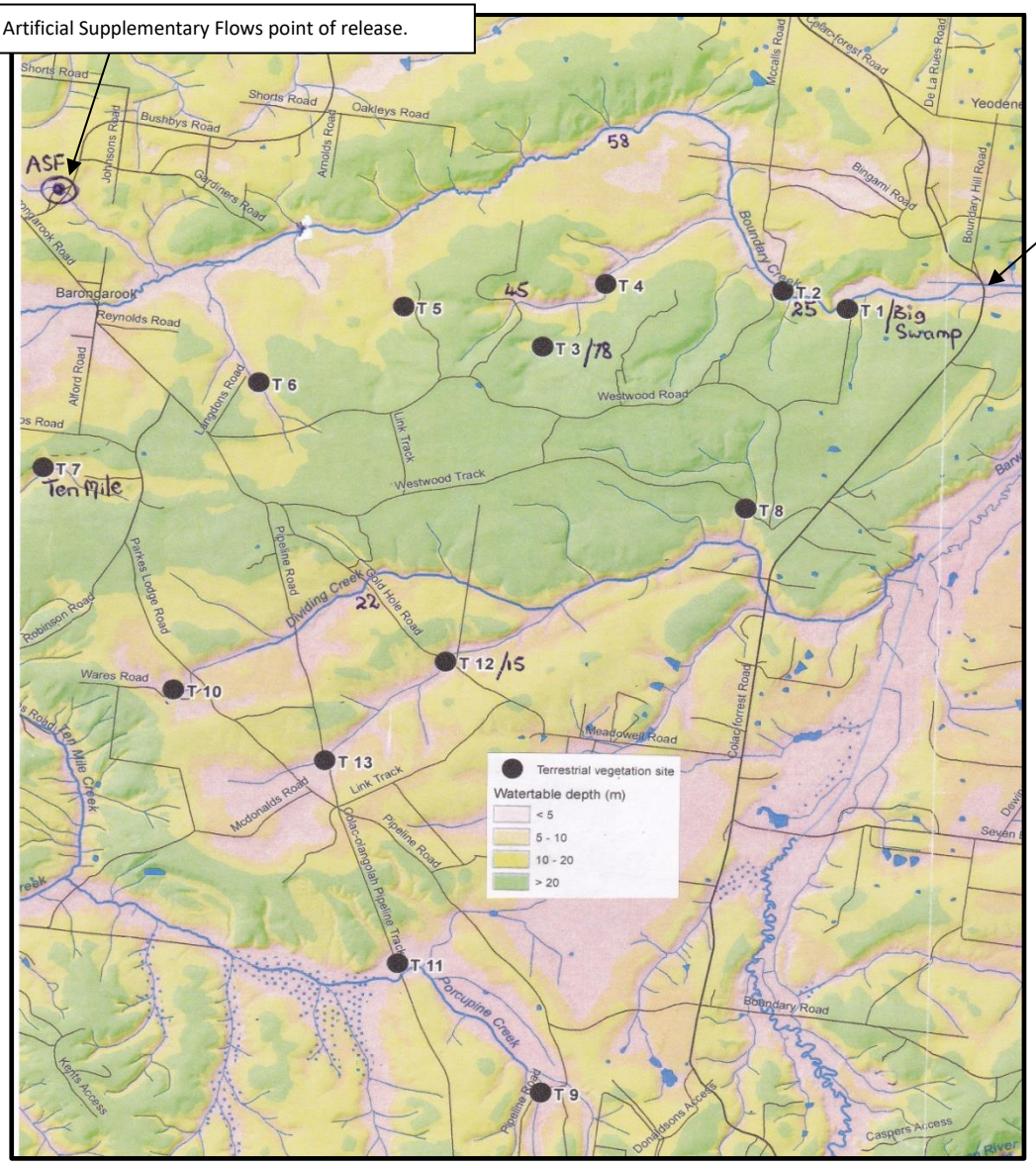
Ten Mile Creek flowing under the Beechy Rail Trail downstream of Maggios Swamp Wetland.



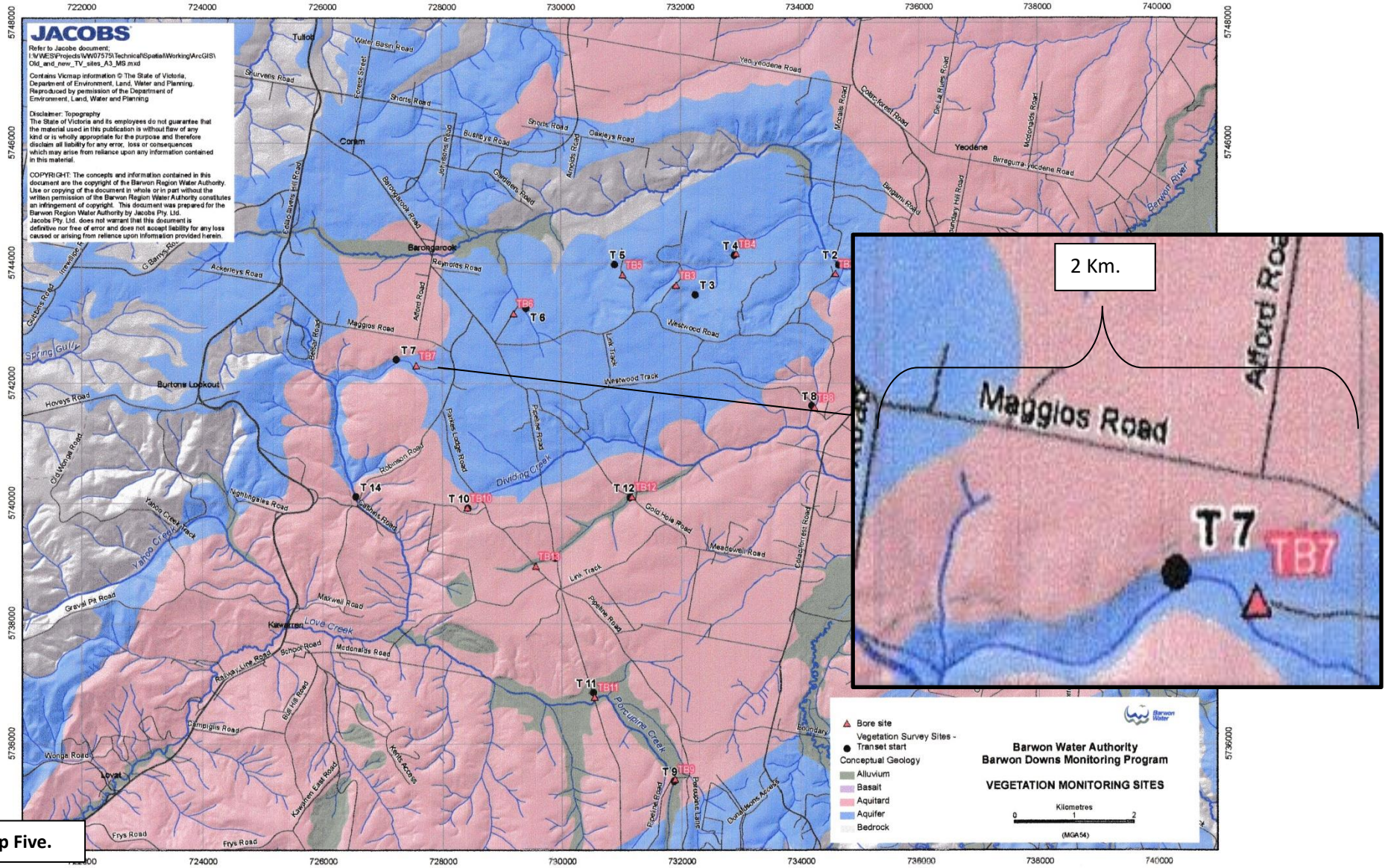
Map Three: Site locations of sites analysed in this study.

Artificial Supplementary Flows point of release.

Stream Flow Gauging Station on Colac to Forrest Road Bridge.



Map Four . **<u>SOURCE</u>: Barwon Water 2015 Vegetation Survey.**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Dividing Creek
Love Creek
Porcupine Creek
Barwon River
Yahoo Creek
Maggios Road
Afford Road
Westwood Road
Westwood Track
Link Track
Pipeline Road
Parkes Lodge Road
Robinson Road
Nightingales Road
Cold Hole Road
Meadowell Road
Maxwell Road
Mcdonalds Road
School Road
Rail Hill Road
Kawarren East Road
Kerfs Access
Donald Cone Access
Parcupine Lane
Boundary
Frys Road
Wonga Road
Hoveys Road
Old Wonga Road
Grevil Pit Road
Ackerleys Road
Reynolds Road
Oakleys Road
Shorts Road
Bushleys Road
Gardners Road
Johnsons Road
Arnolds Road
Mcoals Road
Colac-forest Road
Dr La Rues Road
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Bungley Hill Road
Water Basin Road
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Map Five.

Table One: Summary of Sites discussed in Otway \Water Book 31.

SITE	1994	2002	2008-09	2015	2016
Site 58. Also numbered Site 2 in 2004 Licence.					
Site 22. Also numbered Site 6 in 2004 Licence.					
Site 15. Also numbered T12 in 2015 survey.					
Site 78. Also numbered T3 in 2015 survey.			Visited		
Site 45.					
Site T1 visited in 2015. **The Big Swamp.**			Visited		
Site 25. Also numbered T2 in 2015.		Site moved			
Site 3 numbered in 2004 L:icence and numbered T7 in 2015 survey.					
Maggios Swamp Wetland.					

Surveyed **Not Surveyed**

Site 58 location was the same for each survey.
Site 22 location varied on each visit but within close proximity.
Site 15 was varied slightly in 2015.
Site 45 did not vary.
Site T1 was visited in 2008 but not reported upon. This area was visited by Carr in 1992 and was referred to as an area of significant wetland.
Site 25 varied on each visit. It was recorded that logistically in 2002 it could not be accessed.
Site 3 was a new site set up in the 2004 Licence and moved in the 2014 modified licence conditions..
Maggios Swamp Wetland was been recommended to be surveyed on numerous occasions since 2008 based on local knowledge, but ignored.

Several of these sites have been given conflicting and confusing grid co-ordinates. Besides being inaccurate and wrongly referenced by SKM/Jacobs, different forms of referencing has also been used to describe a site. (see page **116-117** for an example).

Site 58 upstream of McDonald's Dam.

This site was surveyed in 1994, 2002 and again in 2008. One reason this site has been included in this study is the continuity of surveys but more specifically it was chosen more for the reason that the first two surveys were completed before the start of the Artificial Supplementary Flow releases (see Maps, pages **26** and **27**). Looking at this site gives some understanding of the negative impact from groundwater extraction before the Artificial Supplementary Flows were released, and the start of recovery these releases then had since 2004 on hydrologically sensitive vegetation (Groundwater Dependent Ecosystems).

Site 58 in 1994.

This community of vegetation type was designated a Wetland by Ecology Australia, with 29 native species and 9 exotic (Total 38). This site was the only example of Swamp Gum Grassy wetland surveyed. It was found to be "***a small localised floodplain of a meandering stream*** "[93] on Boundary Creek.

"***Water of 40 cm (to 80 cm in the stream), permanently inundated at least in part. There is evidence of this swamp being drier in the past (i.e. dieback of Swamp Gums) and only seasonally inundated***."[93] Since serious extraction began during the 1982-83 drought up to 1994, Boundary Creek had dried up on 10 occasions.

One species of national significance (Showey Lobelia) and 10 of regional significance (Water Ribbons, Streaked Arrow Grass, Slender Speedwell, Pomaderris, Knotweed, Australian Gipsywort, White Pulsane, Australian Sweet Grass, Large Bindweed and Leafy Flat-sedge), were found.

NOTE: Page 24 of the 1994 survey lists 32 species, page 203 lists 38.

Site 58 in 2002.

When re-surveyed in 2002[95] there were 14 less native species, one new native and one new exotic. This report stated that for the most part the re-survey revealed little or no change. Having 14 native species or 50% disappear tends to indicate a reasonable change and could be regarded as somewhat more than "little." The resurvey was not carried out in the "***same precise location***."[95]

Despite this the vegetation at this site was regarded as very rare. The Showey Lobelia was once again found but the vegetation had changed at Site 58. Site 58 was shifting from a Swamp Gum Grassy Wetland of 1994 to a reclassification in 2008 to Sweet Grass Wetland.

Vegetation changes included:

a. ***The presence of fewer indigenous species:*** (50%)
b. ***Higher cover of a few species, notable Spotted Knotweed (Persicaria praetermissa) which is now the overwhelming structural dominant:***
c. ***A decline in cover of other species (e.g. Leafy Flat-sedge, Cyperus lucidus) probably because of increased cover of Spotted Knotweed (P. praetermissa);***
d. ***High ongoing mortality of Swamp Gum (E. ovata) as a result of blowing over (windthrow) (as noted by Carr and Muir 1994).*** [95]

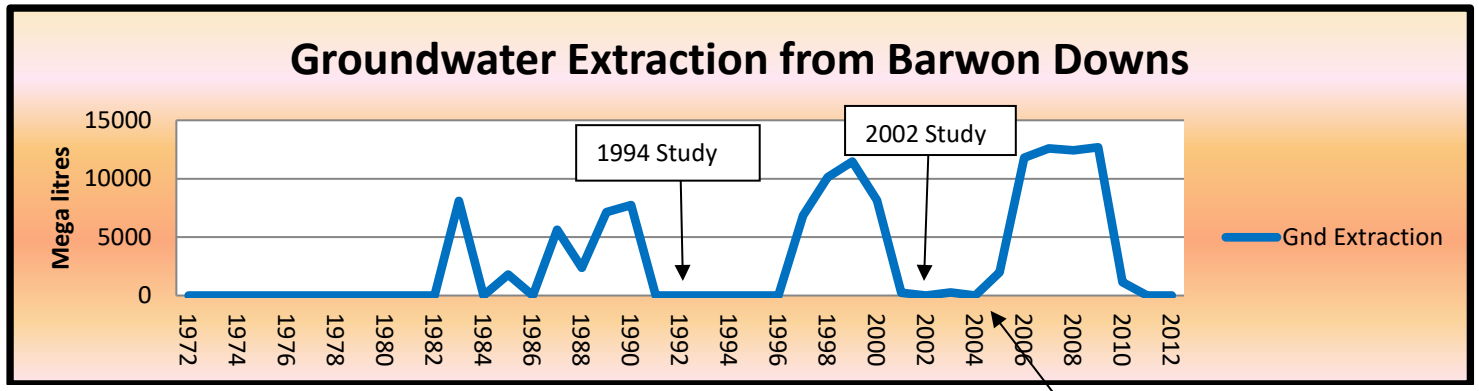


CHART ONE: **Groundwater Extraction from the Barwon Downs Borefield.**

Site 58 is on Boundary Creek and has experienced periods of no flows once pumping commenced. Periods of no flow continued up until the 2002 survey. After this survey the Artificial Supplementary Flow releases commenced and have ensured Site 58 receives a regular and consistent flow, with little variability.

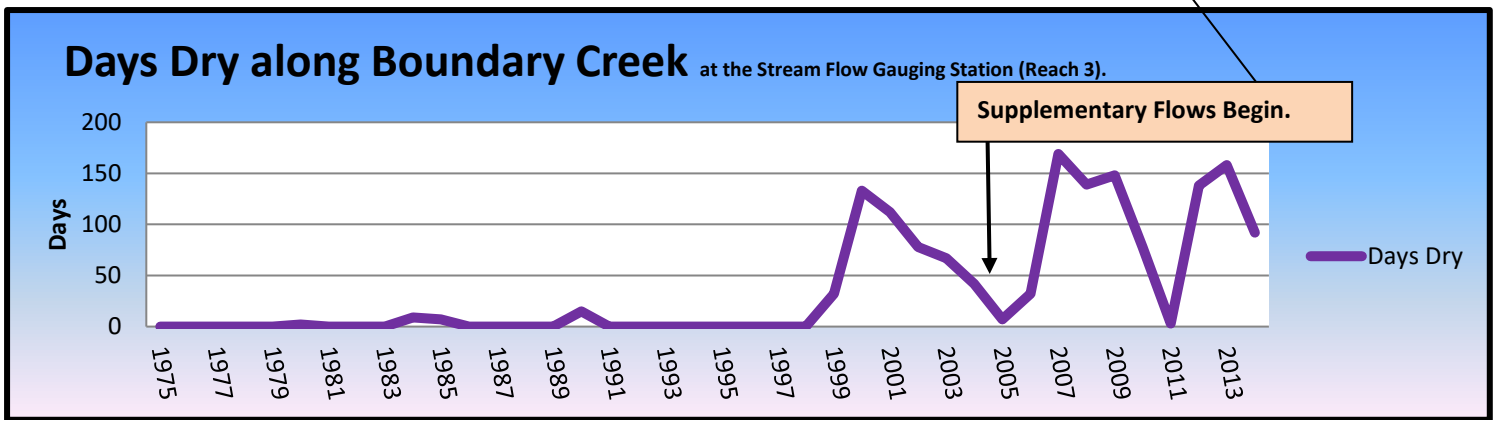


CHART TWO: **Days of no Flow at the Colac Forrest Stream Flow Gauging Station. (SOURCE: Vic Water Warehouse & Barwon Water)**

Map Page **26** shows the release point of the Artificial Supplementary Flows. This map also shows where these flows disappear into the Big Swamp near Site T1.

1980 – 2 days of no flow, 1984 – 9 days. 1985 – 7 days. **1990 – 15 days.** 1999- 32. 2000 – 133. 2001 – 112. 2002 – 78. 2003 – 67. 2004 -42. 2005 – 7. 2006 -32. 2007 – 169. 2008 – 147. 2009 – 135. 2010 – 78. 2011 – 3. 2012 – 159. 2013 – 158. 2014 – 92. 2015 – 107.
In 2016 Jacobs made this misleading statement "***This highlights that Reach 3 ceased to flow on one occasion in 1990 and then for periods in every year since 1999.***"

After the 2002 survey report the Artificial Supplementary Flows were started and these releases ensured a constant flow past Site 58 from 2004 up to the time this site was resurveyed in 2008

The SKM 2008 results found:

1. This Site was re-classed as a swampy floodplain.
2. Hydrologically this site was highly sensitive.
3. Is a swamp on a floodplain of Boundary Creek.
4. With water of 10-20 cm deep under more-or-less floating vegetation for the width of the floodplain.
5. Classed under the EVC as Sweet Grass Wetland. (This being a different classification to the 1994 rating.)
6. Hydrological regarded as dependent, highly sensitive aquatic or amphibious vegetation requiring continual moisture.
7. A similar species richness was evident as in 2002 (21 species) versus 2008 (22 species).
   (This contrasted strongly with the 1993-94 when 38 species were recorded, many of which have disappeared.)
8. Moisture levels were elevated well above those expected.
9. Herbaceous vegetation healthy and vigorous due to availability of water.
10. Woody vegetation dead or under stress due to water-logging.
11. Data indicates that groundwater level has dropped by 9-10 metres between 1986 and 2008 (60-80% due to groundwater pumping). In 1986 the groundwater level was between 0 m and 1 m below the surface.
12. The floristic richness decline since the 1994 survey has been interpreted as a changing response to water availability – first a deficit of water due to drought and groundwater pumping and then restored flows.
13. The 2008 richness of vegetation could be attributed to restored flows.

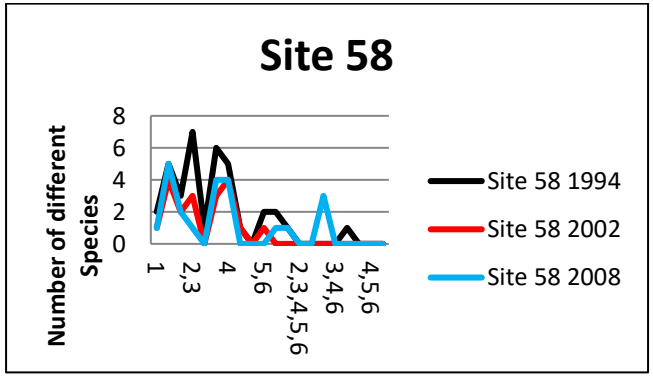
Overview made by SKM in General Discussion Regarding <u>All</u> Sites in this 2008 report.

1. Major changes occurring in the regional landscape scale as a result of drought.
2. Universally indigenous and exotic vegetation has been under severe water stress.
3. Moisture stress includes – death, reduced performance, poor growth, premature death of annuals, failure to flower, small crops of flowers or abortion of flower buds, reduced seed set or failure of seed crops, and reduced recruitment.
4. It is probable that almost the entire regional flora has suffered stress in this way.

5. These stress- induced changes are liable to lead to reduction in cover in hydrologically sensitive plant species, better performance in other species, extinction of species and/or populations and increased colonisation of weed.
6. A range of changes were noted from little through to major.

Variance of species found from survey to survey.

Site		1994		2002		2008								**Natives over all survey periods.**	
58		Native	Exotic	Native	Exotic	Native	Exotic								
	Total species each survey	29	9	15	5	16	7							Species lost...	17
	Same species as previous surveys			14	4	11	6							Species at all surveys	10
	New species from previous surveys			1	1	2	1							Species at 1 or 2 surveys	22
	Lost species from previous surveys.			15	5	18	3							**Total species**	32



Categorisation of Vegetation

Moisture dependency categorisation as used by SKM for the 2008 survey.

1. Obligate aquatic (emergent, submergent or floating) or amphibious species.
2. Requires + or - constantly moist or saturated root zone; tolerant of periods of moderate inundation.
3. Occurs in situations with seasonally/intermittently wet root zone but substrate may be relatively dry for part of the year.
4. Occurs in relatively moist environments (e.g. lower slopes, southern aspects or drainage lines) but with freely draining substrates; roots may have access to water table at depth.
5. Opportunistically occurring in wet/moist environments(e.g. on small rises or stumps) but normally considered "dryland" species.

Doug Frood added the sixth category.

6. Dryland species with no groundwater dependency.

Jacobs maintains species fitting into the categories 1-4 are groundwater depenedent.

Summary Site 58.

In 1986 Farmar-Bowers found that the water dynamics in the area and at sites such as Site 58, had been relatively stable for some considerable time,[116] and that under natural fluctuations of drought and wet periods the vegetation would have adapted to these conditions changing very little. However, substantial ground water extraction would alter this natural fluctuation considerably, upsetting the natural balance. Consequently it is extremely misleading to give the impression that Site 58 fits neatly into the 2008 SKM study overview, an overview stating

and expressing the notion that regional flora had in general terms suffered stress. There may have been visible signs of stress suffered with dry-land type vegetation that relied on rainfall events, however, this study was not looking at dry-land sites. Also, "control" Site 3 did not exhibit signs of stress when surveyed during the 2008 study (see pages **63-72**). By 2008 Site 58 had a constant flow of water via the releases of the Artificial Supplementary Flows and the wetland vegetation was regenerating. The 1994, 2002 and 2008 studies were specifically looking at water sensitive vegetation that could be affected by groundwater extraction at the Barwon Downs Borefield. Sites were chosen at specific locations where this was the strongest of possibilities. If the natural aquifer discharge or influence was to drop below the normal Dynamic Equilibrium Water Level Zone (see page **35**) as a result of groundwater extraction, these sites would then show signs of impact, just as Site 58 did between 1991 and 2002.

At the time of the 2008 survey other Otway Ranges hydrologically sensitive wetlands outside the influence of the Barwon Downs Borefield, had little to no change. Just over the aquifer divide/restriction, hydrological sensitive sites in the Ten Mile Creek and Loves Creek catchments had shown no form of such stress at the time of the 1994, 2002 and 2008 surveys. From the Otway Ranges and foothills perspective the only observable detrimental impact on aquifer groundwater dependent ecosystems being affected, were those inside the area of residual drawdown from the Barwon Downs Borefield.

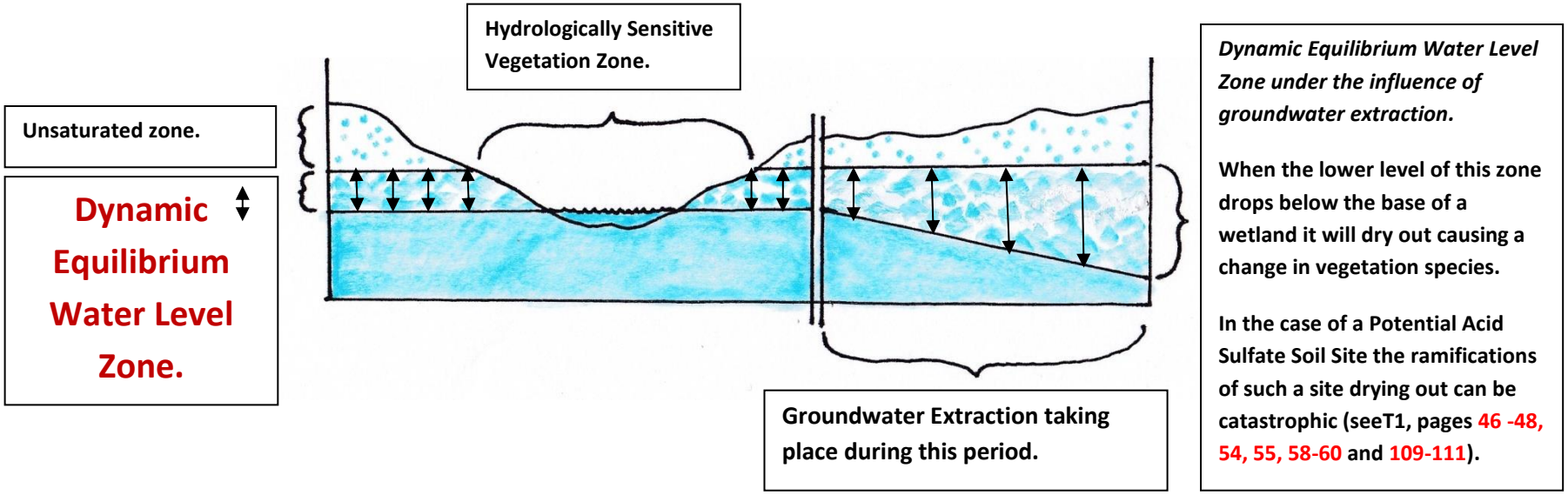
Farmar-Bowers included these two statements in his 1986 report that supports the notion that under conditions where there is no significant groundwater extraction the hydrologically sensitive vegetation maintains a basic equilibrium.
"*Current water tables appear to be quite stable and there is little movement between seasons or years. (J. Leonard Pers.Com.)*"(116)
Note little movement between seasons or ***years***.
"***Aquifer pumping during droughts, as is proposed, would tend to exacerbate the effects of natural variability by extending the effects of drought.***"(116)
Even up to the present time hydrologically sensitive vegetation in the Ten Mile and Loves Creek Catchments has shown little impact from the climatic changes that have taken place before, during and since the millennium drought. Aquifer discharge acts as a buffer against drought. Similarly, aquifer discharge sites in the Barwon Downs Borefield area should have also benefitted from the same form of buffering but haven't.

The fact that 14 native species disappeared from Site 58 between the 1994 and 2002 surveys is very significant and this is a much bigger change than would be expected under normal "***natural variability***." Happening over such a small timeframe is also most unusual for such changes to take place as a result of natural variability. Between the 1994 and 2002 vegetation surveys, groundwater extractions from the Barwon Downs Borefield had significantly lowered the water table in the vicinity of Site 58. This could easily explain the loss of 50% of species at the site by 2002. The release of the Artificial Supplementary Flows also explains the return of the site to a permanent wetland. From 2004 this regular release of water would negate the normal seasonal variability explaining the death and stress to some species surveyed in 2008, species that relied on this variability.

Dynamic Equilibrium Water Level Zone.

Rick Evans (SKM) explains this natural variability. He explained that there is a zone where the watertable naturally rises and falls to the "beat" of nature, I have coined this the Dynamic Equilibrium Water Level Zone. During drier periods and including droughts the watertable drops and then recovers in wetter periods. This is what Farmar-Bowers described as "***natural variability***."

However, once groundwater extraction on a massive scale is placed into the equation, the lower end of the Dynamic Equilibrium Water Level Zone will drop further than can be justified as normal. A return to a normal natural variable state will take much longer and will depend on the amount of groundwater extracted. Any effect will be magnified if the water is extracted during dry or drought events.



Site 58 was chosen to show what can happen to a hydrologically sensitive site when the watertable is significantly and permanently lowered over a relatively short timeframe, with 14 native species dying out between 1994 and 2002. Lower the watertable and the groundwater dependent ecosystem changes allowing drier tolerant species to move into the area. Once the Artificial Supplementary Flows were released the site showed a remarkable recovery back to a wetland type setting. The natural variability of the Dynamic Equilibrium Water Level Zone was not only returned but kept at its upper level masking any impact from groundwater extraction.

Site 58 is a good example showing the detrimental impact that can take place by significantly lowering the watertable at a groundwater dependent ecosystem site. The release of the Artificial Supplementary Flows further highlights how it is possible for a wetland to recover.

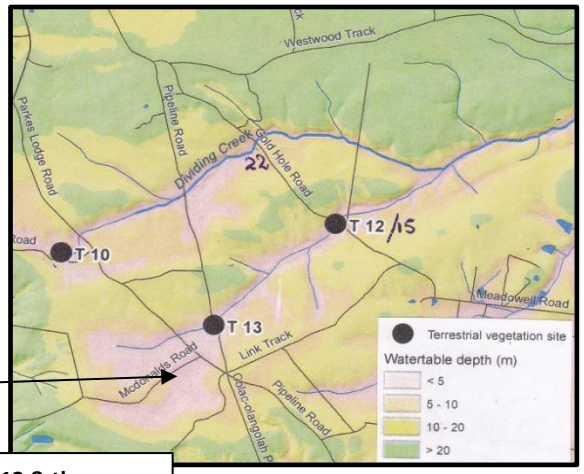
Sites 15, 22, 25 and 45 (See locations pages 26-27).

In the 1994/2002 surveys Ecology Australia categorised vegetation into 6 community types. Vegetation Community 4 (Swamp Gum Forest), Community 5 (Scented Paperbark, Woolly Tea-tree Swamp Forest or Scrub) and Community 6 (Wetlands) were stated as three communities that would display floristic and structural change following hydrological modification. In 2008 SKM reversed the numbering, 1 being the wettest and 6 the driest category (see page 33). To avoid confusion, discussion in this book Book31, refers to the 2008 categorisation used by SKM. In this regard Ecology Australia would class categories 1, 2 and 3 as vegetation most likely to display floristic and structural change following hydrological modification.

In 1994 Sites 15, 22, 25 and 45 were categorised by Ecology Australia as a Community 5.0 Scented Paperbark (Melaleuca squarrosa) – Woolly Tea-tree (Leptospermum lanigerum) Swamp Forest or Scrub. Under the SKM categorisation these fit into the categories 1 and 2.
These sites were described as... "***swampy floodplains of streams, swamps and swamp margins***" ...with the... "***water table seemingly at or near surface, with free water often present; subject to regular seasonal inundation – whole site could be flooded to c. 20 cm or more for weeks or months***." These sites most definitely were regarded as hydrologically sensitive sites worthy of inclusion in the 1994 survey.

Site 15 renamed T12 in 2015.(See Appendix 6, page 161 for species lists).

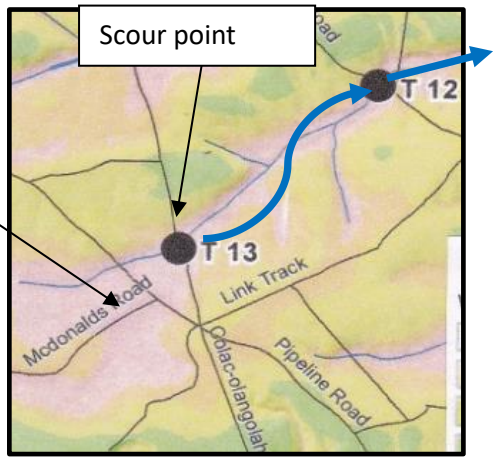
When visiting Site T12 as per the Jacobs map location (see page 27) the site co-ordinates given in the report appear to be 1500 metres out on the easting and over 1000 metres on the northing. Coincidently, these Jacobs coordinates are the same ones given for the T13 site. To add further confusion, the T13 site is not where it is marked on one of the Jacobs map. It has been relocated to a site on the Parks Lodge Road. The T12 and T13 sites have been given the same co-ordinates which is not possible as they are approximately 2000 metres apart.



New location of Site T13.

Jacobs gave the same coordinates for T12 & the new T13. (E729592, N5738949).
****
Site15/ T12 by my GPS is E731169, N5740134.

Site 15/T12 is on a tributary of Dividing Creek and the Otway to Colac water supply pipeline runs under this tributary at Site T13. At this point there is an outlet allowing the pipeline to be scoured flowing water into the Dividing Creek tributary.
This water then flows downstream through Site T12.



Site 15 was surveyed in 1994, 2002. In 2015 Site T12 was chosen in this location. Between the 1994, 2002 surveys, four new native species were found (Swamp Wallaby-grass, Slender Twig-sedge, Forked Sundew and Hard Water-fern); while 8 natives found in 1994 went missing (Creeping Bossiaea, Tufted Centrolepis, Tall Rush, Broom Rush, Rosemary Everlasting, Soft Tussock-grass, Groundsel, Slender Fire-weed and Ivy-leaf Violet).
There were several sites in the 2002 resurvey that displayed significant changes, however, Site 15 was not referred to as one of these being regarded as a site of little change.. "***The resurvey of the vegetation at 24 sites in this study for the most part revealed little or no change***

SKM stated the results of the 2002 resampling of Site 15 indicated no vegetation changes even though 4 new native species (in the wet categories 1,2 range) and 10 native species (3 categorised in the 2,3 range & 7 in the drier category ranges) not being found . However, this site was still regarded as a high quality, intact perennial woody vegetation – Swamp Gum Forest and Scented Paperbark site (See Appendix 6, page **161** for species lists).

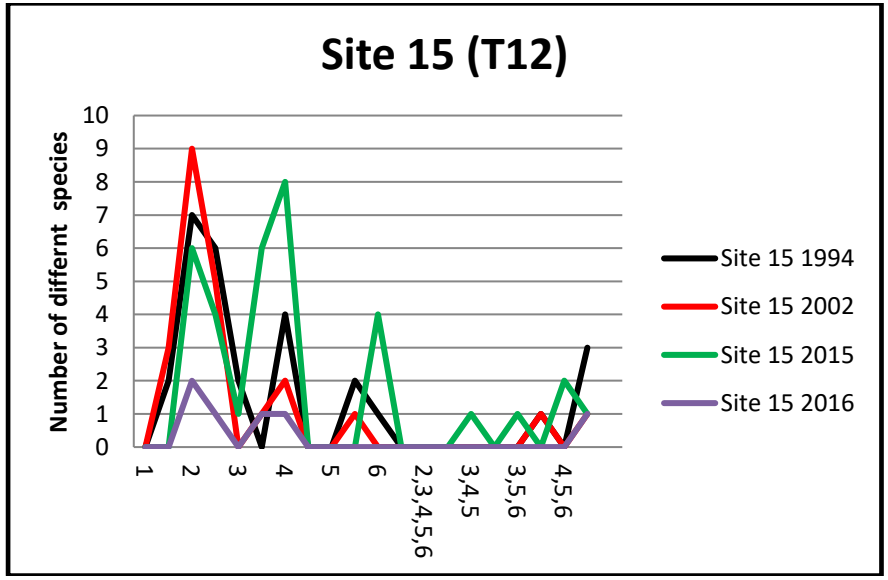
Between the 1994 and 2002 surveys there were 9 true wetland indicator species identified that disappeared (categories 1 and 2, see page **33**). Frood had this to say in 2016, "***Either the vegetation at the quadrant has become much drier and denser, or the co-ordinates are insufficiently accurate to locate the original site.***" In 2016 the shift to drier type species was most obvious. Frood observed three native species from category 3,4 not found in earlier surveys.

In 2015 when Jacobs resurveyed in the same vicinity twenty seven new native species and two different exotic species were found that had not been identified in this locality in any of the previous surveys. Twenty of these 27 native species were identified by Jacobs as groundwater dependent. However, of these supposedly groundwater dependent species only three fitted into the categories 1, 2 and 3 rated by Ecology Australia and SKM (see page **33**) as vegetation most likely to display floristic and structural change following hydrological modification. One of the 20 was category 2; one was category 2/3 and one was category 3. The other seventeen of the 20 species were in categories 3/4 and

above. This would suggest a huge shift towards vegetation requiring drier conditions despite the occasional scouring from the Otway to Colac Pipeline.

Whether Frood visited the exact site of the original Site 15, or Site T12, there can be no doubt that the vegetation in the vicinity has, over the period of 25 years, become substantially and significantly drier.

Site		1994		2002						2015 T12		2016 D. Frood		**Natives over all survey periods.**	
		Native	Exotic	Native	Exotic					Native	exotic	Native	Exotic		
15	Total species each survey	26	2	19	3					41	2	8	-	Species lost...	26
	Same species as previous surveys			15	2					14	0	5	-	Species at 1 or 2 surveys	48
	New species from previous surveys			4	1					27	2	3	-	Species at all surveys	4
	Lost Species from previous surveys.			10	1					8	3			**Total species**	52



Site 22. (See Appendix 7, page 163 for species lists).

This site was surveyed in 1993, 2002 and 2008 (renamed Site 6 in the 2004 extraction licence). In 1993 and 2002 Ecology Australia described this site as a Scented Paperbark – Woolly Tea-tree Swamp Forest or Scrub, of very high vegetation quality and of State significance. Ecology Australia found little difference between these two surveys. In 1993 there were 19 native species and 1 exotic species identified. In 2002 there 17 native and the same exotic species found. Three different native species were identified – very little change. (See Appendix 7, page 163 for species lists). The site was still categorised as a level 2.

However, by the time of the 2008 survey, marked changes had taken place. 33 native species and 6 exotic species were found with 18 different native species identified. Dry-land opportunistic species were moving into the site.

It would appear that because there had been little change between the 1993 and 2002 surveys the designing of the 2004 licence conditions concluded that this would be an excellent **control site** to be used as comparison in 2008 against those sites closer to the borefield and within the area of substantial drawdown. Unfortunately this site was also well within the residual drawdown area of the Barwon Downs Borefield and by 2008 groundwater extraction had escalated to over 11 000 ML/year creating a 60 metre cone of depression before pumping ceased in August 2010 (see Maps, pages 18-19 & 107, 123, 121). The area of impact was spreading considerably. Considering the Permissible Annual Volume for groundwater extraction was limited to 4,000 ML/year in the late 1990s, it is little wonder that impacts began to take place further and further from the borefield. The non impact limit for groundwater extraction was considered to be 1,500 ML/year.[116]

In the 2008 survey, SKM made these observations regarding Site 22.

- The vegetation is now twice as species rich.
- Dry-land opportunistic species "invading" as moisture levels have declined.
- Other opportunistic colonisers with wide dispersal capability of which 4 were non-wetland herbaceous weed species were present.
- There was significant decline in some aquatic species that were formally abundant in the water which previously occupied the site.
- Many of the moisture dependent sedges and rushes, while still maintaining cover, were clearly drought type stressed with much dead leaf tissue and little flowering occurring.
- Flowering in many other species was identified as poor.
- There was no free water as observed in previous surveys, e.g. c. 40 cm deep in 1993-4.
- The muddy/peaty substrate was considerably cracked and drying.
- Oxygeneration of previously anaerobic environment was observed.

- Further significant vegetation changes can be expected to occur should dry conditions persist.

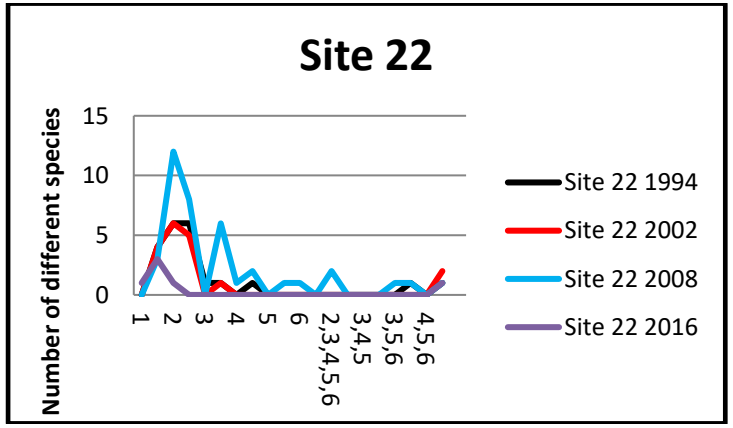
At least an effort was made to ESTIMATE the groundwater level during the 2008 survey. In 2008 it was estimated that the groundwater level in 1994 and 2002, was 15 metres below ground level. This seems strange as the site was inundated and the wetland was rich in water dependent species in the 1993 and 2002 surveys.

The original 1993 survey stated "***water table seemingly at or near surface, with free water often present; subject to regular seasonal inundation – whole site could be flooded to c. 20 cm or more for weeks or months.***"(93)

Further, the groundwater level in 2008 was *ESTIMATED* to be 17 metres below ground level. Therefore, the drop in groundwater up to 2008 was set at 2 metres. Interesting. The marked changes at Site 22 should have been compared against "control" Site 3 in this 2008 survey. Site 3 had maintained its integrity but no comparison was made.

(The 2008 data set missed recording one of the native species previously identified in 1994 and 2002.)

Site		1994		2002		2008						2016 D. Frood		**Natives over all survey periods.**	
		Native	Exotic	Native	Exotic	Native	Exotic					Native	Exotic		
22	Total species each survey	19	1	17	1	32	6					6	-	Species lost...	6
	Same species as previous surveys			14	1	14	1					5	-	Species at 1 or 2 surveys	26
	New species from previous surveys			3	0	18	5					1	-	Species at all surveys	12
	Lost Species from previous surveys			5	0	4	0							**Total species**	38



When Frood visited this location he found it "...***somewhat confusing, as the vegetation at the specified co-ordinates was referable to the quite different and considerably drier EVC Damp Heathy Woodland*** " Frood found when attempting to locate the co-ordinates as set out in the earlier surveys, that a road side location was better suited to the results of the 1993 and 2001 surveys. The species Frood noticed at this site have been recorded on this graph. He also made these observations of the area. "***While this area was dry at the time of observation, there were indications of dramatic ecological processes in action. There was substantial cover of the dry remains of small mat-forming aquatic Myriophyllum pendunculatum, indicating it had performed well during the preceding wet phase.***

The differences between the 1993 and 2001 sampling period appear to relate to seasonal variations and the capacity to identify individual species, rather than providing any indication of more substantial ecological drift." The seasonal variations between the 1993 and 2001 surveys were not reflected in the dramatic ecological processes that were apparent in the 2016 survey.

The site with the co-ordinates given in the 1993, 2001 and 2008 surveys was a distance from the site observed close to the road access. However, the co-ordinated site when found was considerable drier and would have been better described in 2016 as an EVC Damp Heathy Woodland. To believe that the co-ordinates could wrongly be mis-read over the previous three survey periods seems unlikely. Frood confirmed that at the site of the given co-ordinates the vegetation showed considerably drier conditions than the survey results of the 1993 and 2001 investigations. Given this and from the comments made on page **40**, there is every indication of a substantial ecological drift.

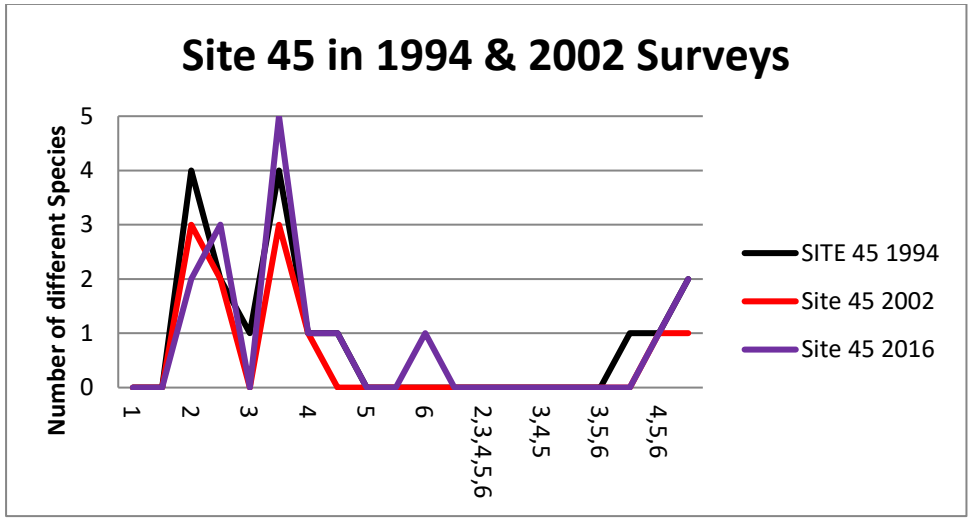
One thing that I find confusing with the 2008 survey results is that even though dryland opportunistic species and weeds were invading the site, there were double the number of species surveyed from category 2. Perhaps having Ecology Australia replaced as the lead investigators has something to do with this.

Despite this, Site 22 should have been kept as a survey site as there had been considerable baseline data collected up to 2008 that could have been used as comparison in future work. Also, considering that this site had been regarded as a control site as designated in the 2004 groundwater licence conditions for surveying in 2008, follow up work post 2008 was most definitely indicated. Having observed Site 22 inundated in 1993 and 2001 and with little change over 8 years, to one of a much drier situation in 2008, needed some explanation and most definitely should have been included in the 2014 survey work.

However, there is enough data already recorded to clearly indicate that Site 22 has undergone a shift from an inundated wetland site to a much drier location. A shift that had also only taken 7 years to manifest itself.

Site 45 was originally categorised as a wetland type location as described on page **36** (See Appendix 9, page **165** for species lists).
Site 45 when surveyed in 1994 and 2002 was found to be of very high vegetation quality and of high regional significance, AND easily accessed. No exotic species were identified on either visit. 14 native species were found in 1994 and 11 in 2002. The 2002 report had this to say... "***The results of the resurvey of quadrant sites indicated no vegetation changes attributable to hydrological changes at most sites, particularly those with high quality, intact perennial woody vegetation – Swamp Gum Forest and Scented Paperbark – Woolly Tea-tree Swamp Scrub or Forest.***" Site 45 was classified by Ecology Australia as Community 5.0, Scented Paperbark – Woolly Tea-tree Swamp Forest or Scrub. As with three other communities, Community 5.0, was stated as having the potential hydrological sensitivity for floristic and structural changes following hydrological modification. However, in the intervening 8 years little had changed at this site. This was an excellent site for follow up comparative study but has never been re-surveyed until done by Frood, 14 years after the 2002 survey.

Site		1994		2002		2008		2009		2015		2016		**Natives over all survey periods.**	
		Native	Exotic	Native	Exotic	Native	Exotic	Native	Exotic	Native	exotic	Native	Exotic		
45	Total species each survey	14	0	11	0							17	0	Species lost...	3
	Same species as previous surveys			11	0							11	0	Species at 1 or 2 surveys	10
	New species from previous surveys			0	0							6	0	Species at all surveys	10
	Lost Species from previous surveys			3	0							3	0	**Total species**	20



In 2016 Frood had this to say "***What are noteworthy about the 2016 sampling are the loss of the fern Blechnum wattsii and the appearance of additional species more representative of the adjacent drier forest (notably Amperea xiphoclada and Acacia verticillata).***"

"***Even allowing for fire effects, there has been a drift towards a species composition indicative of a drier site over the past 15 years.***" And, 6 of those years have been since the Millennium Drought broke. Site 45, is another site showing a clear indication of impact from groundwater extraction.

Site 25(See Appendix 8, page 164 for species lists).

This Site(s) has a chequered history. It was surveyed in 1994 and was classified by Ecology Australia as a Community 5.0, Scented Paperbark – Woolly Tea-tree Swamp Forest or Scrub. The location has maintained this category and site name though the exact site location changed in later surveys. Each consecutively changed Site 25 has always been located in the Sb8 zone (see Map, page 47) that Ecology Australia rated as of State significance.

In the 2002 survey, Site 25 was not accessed because of "***logistic difficulties***" and was re-located approximately 200 north but was still called Site 25. In 2002 "***observation suggest much drier conditions, as expressed in the lack of vigour and reproductivity in the dominant moisture-loving species.***"[95] The only other reference to this "new" Site 25 in 2002, was in regard to groundwater drop under the site due to groundwater extraction and drought. Without any pumping the modelled level calculated the drop would have been 1.22 metres. The drop caused by groundwater extraction was modelled or estimated at 8.5 metres. Observable data showed the water table drop to be much more.

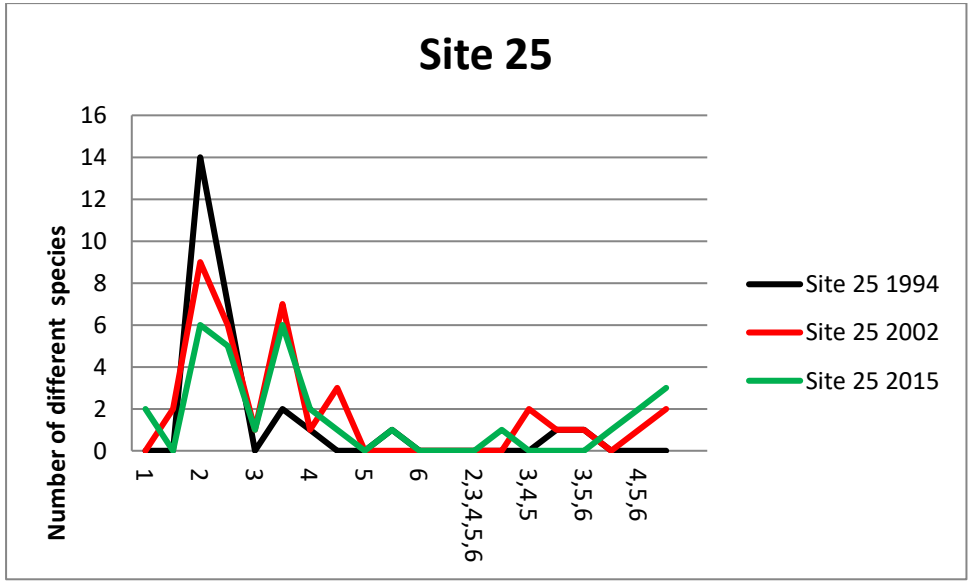
Then in 2004 the licence conditions included Site 25 as a site that had to be included in the 2008 survey. However, Site 25 was moved once again and... "***The quadrant data cannot be compared directly with the data from 1994 due to a somewhat different location.***"[94] In the 2008 report there was no discussion made regarding the data collected in 2002. Strangely the species data sheet of 2008 included the species data for both the 2002 and 2008 surveys. A direct comparison was being indicated. At the 2008 "new" site there were 32 native and 5 exotic species identified. In 1994 there were 25 native species identified and 2 exotics. The species list of 2008 indicates 18 native and 4 exotic species different to the ones identified in 1994. Despite the sites being stated as "***not directly comparable***" the comparison of species in an area of similar hydrologically dependent vegetation (see page 47) pre groundwater extraction, makes interesting reading.

Another interesting comment made about the 2008 Site 25 is... "***Much of the Swamp Scrub section of the quadrant had been subjected to severe windthrow; mature E. ovata were also felled in the same event.***" Little explanation for this windthrow was given. Beside the obvious, a severe weather storm, drier conditions will place stress on the ecosystem to such a degree that the health of Swamp Scrub Forest would decline and root structure could not withstand the normal wind conditions that passed through the area. Drier conditions would also bring about Actual Acid Sulfate Soil conditions in the peats of the area. The 2008 report hinted at this saying that the windthrow was due "***in part attributed to increased stability because of weakening of the oxidised sub-strates (peaty soils.)***" (Perhaps the word "*instability*" rather than "*stability*" was intended in this statement)

Once again Site 25 was moved when conducting the 2015 hydrologically sensitivity vegetation sites. And even though this site is close to the 2008 site, the 2015 data has been claimed once again as "***not directly comparable***." The 2015 report sates... "***The windthrow noted in 2008,***

attributed to a drying of the upper soil strata, was not noted at the transect assessed." However, by this stage Site 25 was being kept saturated due to the influence of the Artificial Supplementary Flows released since 2004.
In 2015 Site 25 had 27 native species identified, no exotics and 12 of the 27 native species identified in earlier surveys were not found in this locality.

Site		1994		2002		2008				2015				**Natives over all survey periods.**	
		Native	Exotic	Native	Exotic	Native	Exotic			Native	exotic				
25	Total species each survey	25	5	-	-	32	5			27	0			Species lost...	29
	Same species as previous surveys			-	-	14	1			15	0			Species at 1 or 2 surveys	49
	New species from previous surveys			-	-	18	4			13	0			Species at all surveys	6
	Lost Species from previous surveys			-	-	11	1			29	6			**Total species**	55



Site T1 (Big Swamp Wetland.) (See Appendix 13, page 169 for species lists)

In 1994 Ecology Australia categorised the area where Site T1 is located as a site with hydrological sensitive vegetation of Sate significance (see Map, page 47, Sb 4b). The Nationally significant and undescribed Small Sickle Greenhood orchid was found in the Sb4 location. The Small Sickle Greenhood is endangered in Victoria and is listed under the Victorian Flora and Fauna Guarantee. This area of Boundary Creek was described as flowing through an unmodified catchment with well developed riparian vegetation. Site T1 was such a site pre 1984.

Although the Big Swamp Wetland was not chosen as a specific site in the 1994 hydrologically sensitive vegetation survey, there was a paragraph given to the impact expected on peat swamps in the area if water tables were lowered.
"***Another highly significant modification to the physical environment is predicted if watertables are lowered in swampy locations, especially those supporting Scented Paperbark – Woolly Tea-tree and other wetland vegetation communities.***"(93) The Big Swamp was such a location.

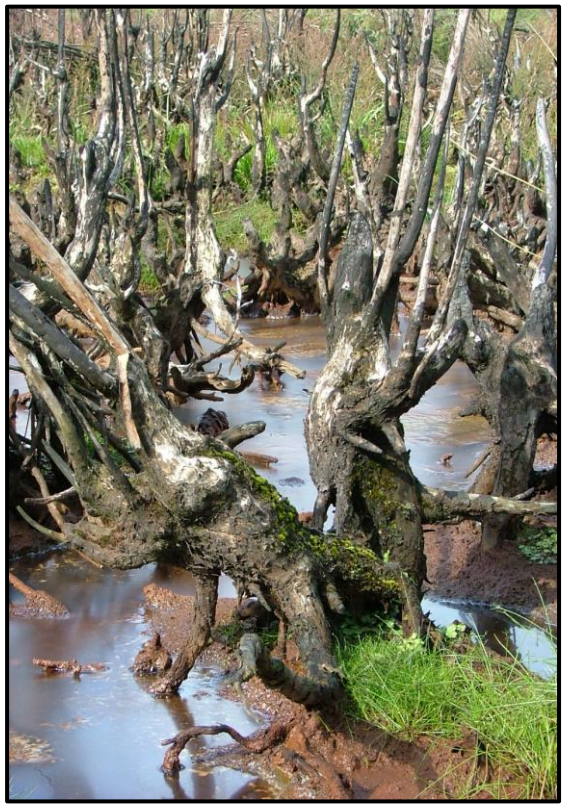
"***When drained, peats become oxidised, lose the greater part of their bulk resulting in slumping of the landscape, and are much more prone to burning –peat fires...***"(93)

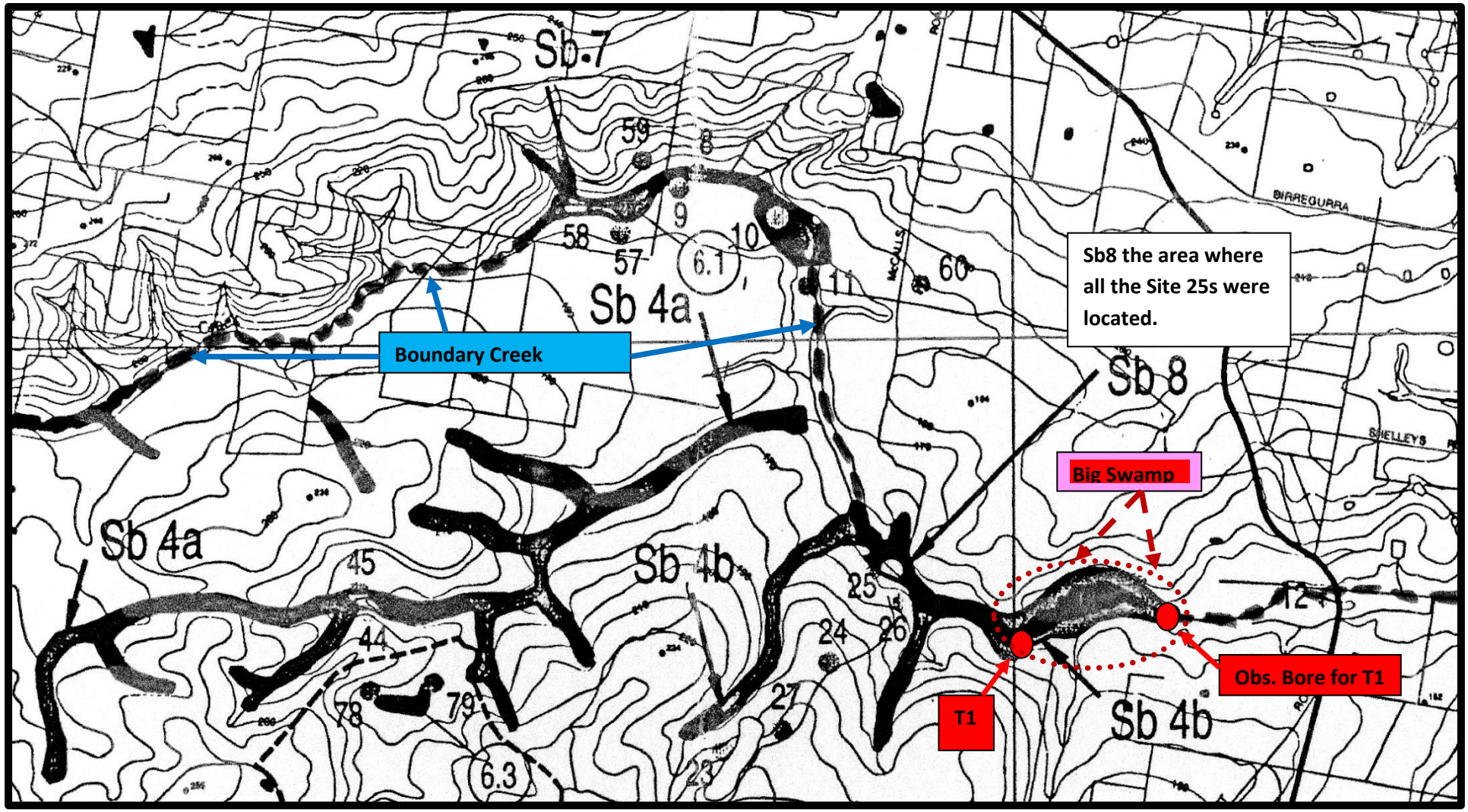
"***The particular physico-chemical conditions prevailing in peaty substrates (e.g. pH, aeration, water and nutrient availability) determine the highly distinctive vegetation in these environments.***"(93)

In 2016 Frood had this to say regarding his visit to the Big Swamp "***Carr and Muir described the vegetation as Scented Paperbark (Melaleuca squarosa) – Woolly Tea-tree (Leptospermum lanigerum) Swamp forest or Scrub, characterised by dense tea-tree or paperbark with scattered emergent Swamp Gums, over a relatively open to dense sedgy or ferny understorey. This site has been effectively destroyed by desiccation and subsequent fire***." "***Patchy colonisation of Leptospermum scorparium, Pteridium esculentum and Eucalyptus ovate has occurred on the peat ash. Other species observed included Eucalyptus viminalis, several juncus species, Microlaena stipoides and Ghnia sieberiana. Some regeneration of Melaleuca squarosa was noted along the drainage-line on the northern side. The wetland element has been completely displaced, and the site is slowly regenerating with a selection of species representative of a far drier habitat than was present in the former vegetation***." "***...the current writer has not seen anything like this level of fire damage to a contemporary peat-based system during sampling and assessments of hundreds of wetland sites across the State. It should be noted that this wetland had persisted over a very long period, presumably millennia, and survived many bushfires prior to the events of the last couple of decades. The peat must have been extraordinarily desiccated to have burnt this comprehensively and to this depth. It is noteworthy that the site is regenerating as a much drier vegetation type than previously.***"

As groundwater extraction at the Barwon Downs Borefield progressed the watertable under the Big Swamp Wetland fell. The top end of the swamp oxidised, acid levels rose, toxic heavy metals were released and vegetation died, and, in 1997 the top end of the wetland caught fire.[45] It was burning again in 1998 and 2010.[32][48][49]

The Big Swamp one year after the 2010 fires.





Map Six: Taken from Ecology Australia 1994 Site Locations Map.

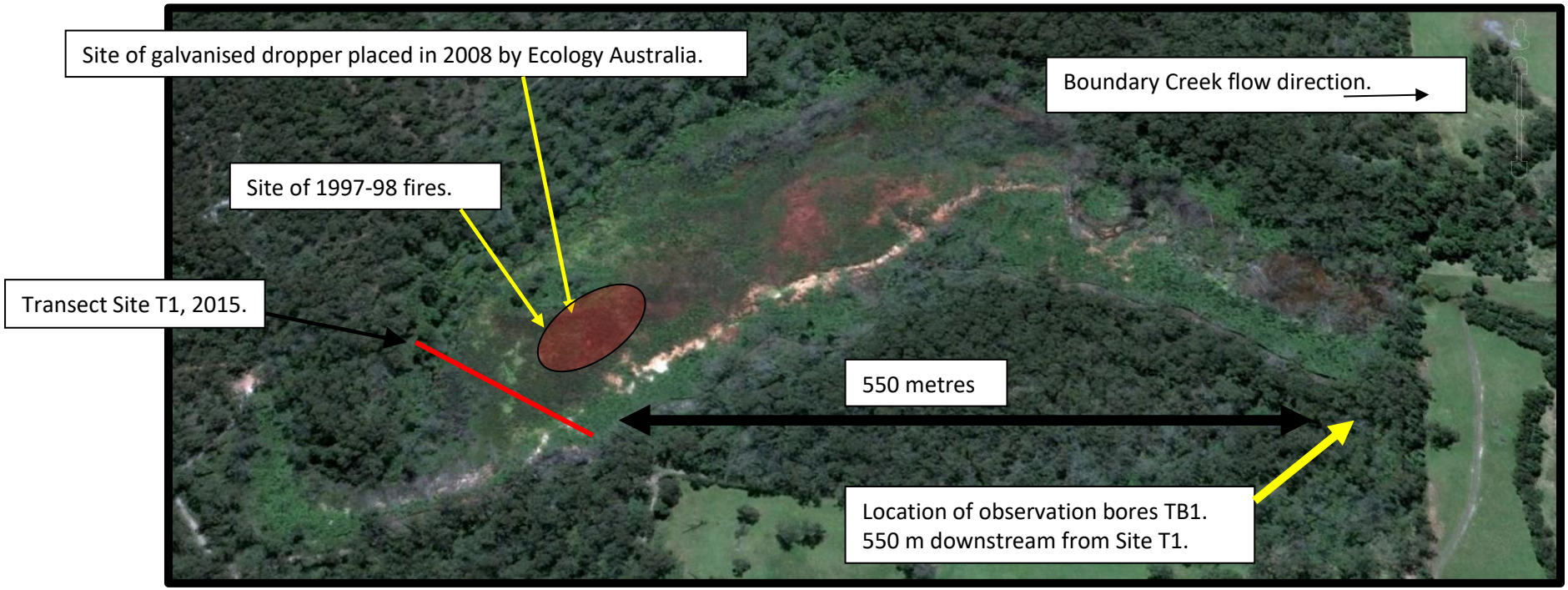
In the 2002 vegetation survey Ecology Australia noted a significant difference in vegetation floristic (species) composition and structure at a site along Boundary Creek that had not been designated a site number in 1994. The condition of the vegetation at this location clearly indicated a reduction in the availability of moisture and was showing a decline in moisture dependent vegetation. This reference is the only hint in the 2002 survey that this observation may have taken place in the Big Swamp Wetland. During the 2008 vegetation survey galvanised droppers had been driven into sites visited. Notably the site of the 1997-98 fire in the Big Swamp also had a galvanised steel dropper placed at the site. This dropper was noted late in 2008. The photographs below on the left was taken in 2008, showing the impact still evident from the 1997/98 fire. This would have been evident during the 2002 and 2008 surveys. The photograph on the right showing dying vegetation further down the wetland and well away from the 1997-98 fire impact would have also been most apparent in 2008. All of the signs indicating catastrophic events taking place would have been evident. Despite Southern Rural Water's assertion that this site would be surveyed in 2008 no report was made.

Top end of Big Swamp in 2008 showing the burnt area from the 1997-98 fire.

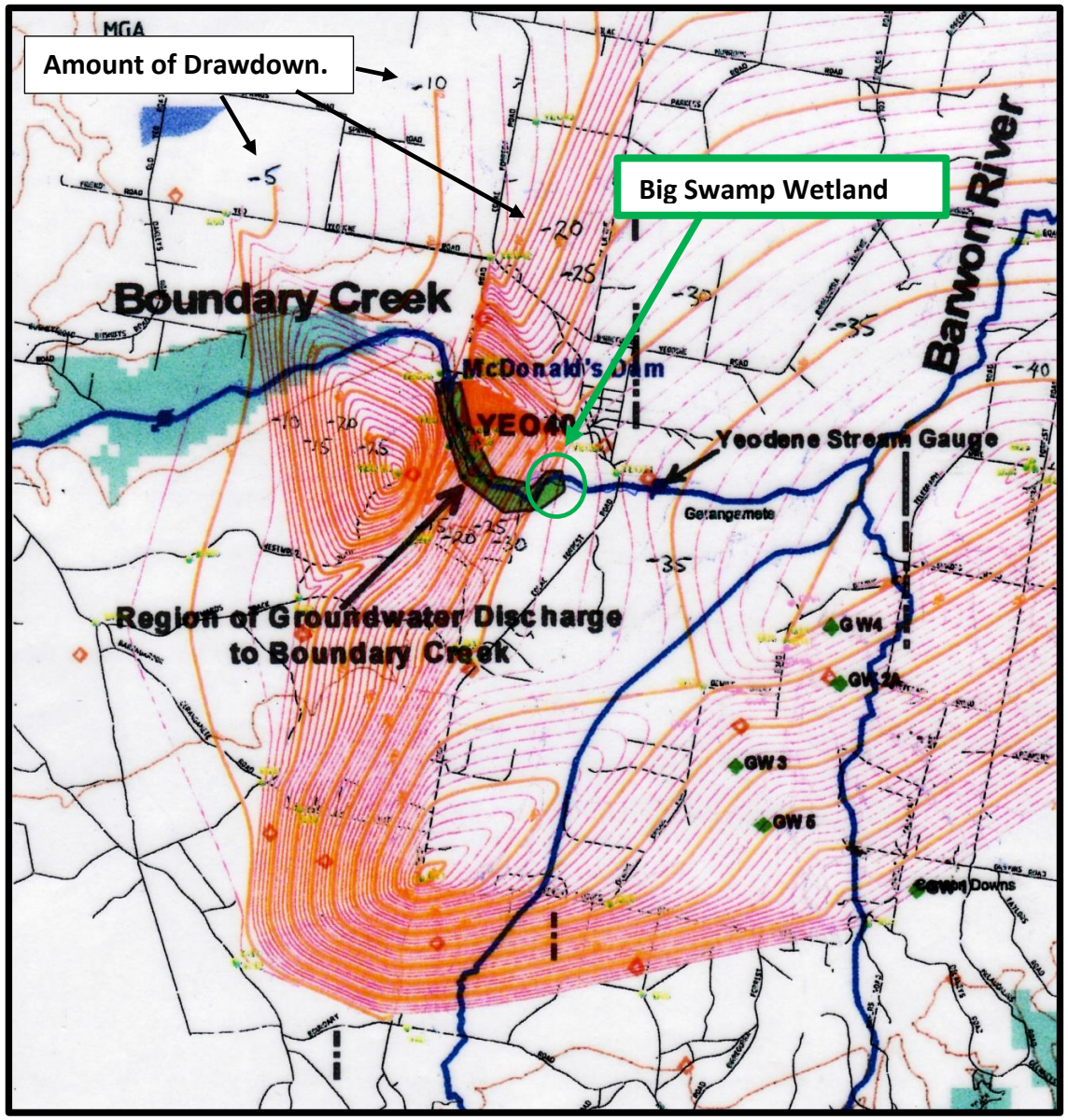
These photos were taken at the same time (2008). The wetland downstream is clearly showing signs of stress from acid creep. The water pH was tested as 2.5 and was indicative that the impact from the Actual Acid Sulfate Soils from higher up the swamp was impacting downstream.

By 2014 Barwon Water had convinced Southern Rural Water that a fresh vegetation monitoring start with 14 "new" sites should be undertaken. Site T1 at the very top end of the Big Swamp Wetland was one of these sites chosen. The vegetation survey of 2015 and had this to say..."***All vegetation assessed was considered to be in good condition with the exception of site T1 which is recovering from recent burning and acid soil and groundwater conditions. No sign of decline in vegetation condition that could be related to past extraction from the borefield was observed, however, the ability to detect such change given this is the first monitoring event at these sites is limited. Specifically no dead shrubs, trees and/or large sedges were observed that could be related to a decline in the groundwater levels.***" The photographs on page **46, 54, 58** and **109-111** tell a different story.

It is relevant at this point to mention that of all the those sites in 2015 close to old sites, they "***... are not comparable as the location has shifted more than 200 m to be closer to the newly established bore and tree water use sampling sites. These locations will enable the analysis of the relationship between any detected vegetation changes and measured changes in groundwater levels....***"



Satellite Photograph of the Big Swamp Sourced from Google Earth.



<u>Residual Drawdown Map Source:</u> Barwon Water 2009.
<u>SKM Map</u>: Residual drawdown Superimposed over SKM Map sent to Barwon Water, "Recommendations for Groundwater Licence Conditions, Figure 3-1 region of groundwater discharge to Boundary Creek." 14 May 2003.

Some facts to consider.

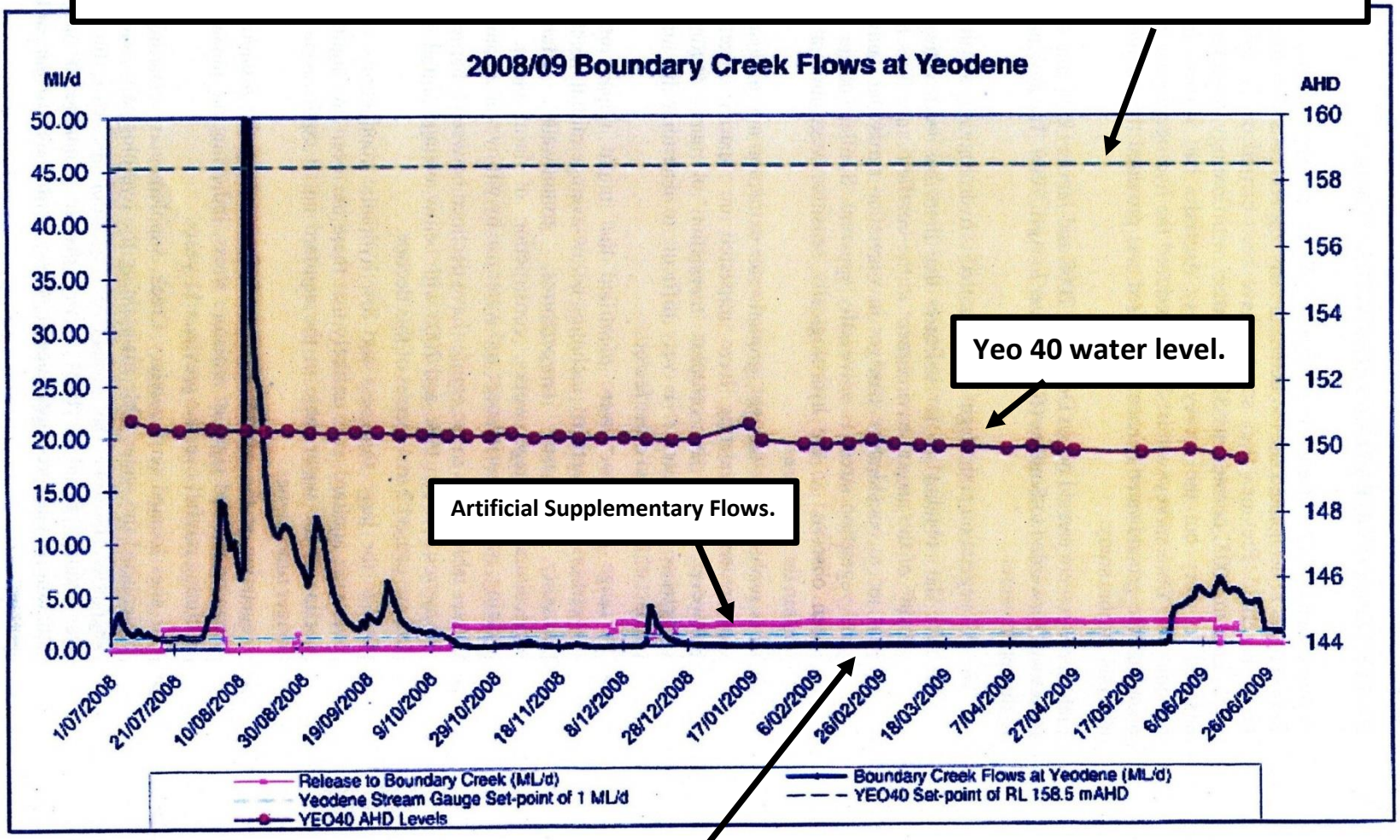
FACT: The 2003 SKM map sent to Barwon Water as part of the lead up to the granting of the 2004 groundwater extraction licence, shows quite clearly that when the aquifer is full under natural conditions, there will be an overflow into the Big Swamp Wetland and Site T1 area.

FACT: The superimposed 2009 residual drawdown map presented in Barwon Water's 2008-09 report to Southern Rural Water, clearly indicates a massive drawdown under the Big Swamp wetlands and adjoining riparian areas.

FACT: On page **51** the data presented in graphical format, also taken from the 2008-09 report, further emphasises the amount of drawdown under the Big Swamp area.

FACT: SKM calculated that dropping the watertable below 158 m ADH in the Yeo 40 observation bore during groundwater extraction episodes, would cause Boundary Creek to stop flowing.

Observation Bore Yeo 40 trigger level of 158.5 m AHD. When the water table level drops below this level Boundary Creek stops flowing. Artificial Supplementary Flows have to be released into Boundary Creek.



Yeo 40 water level.

Artificial Supplementary Flows.

Days of no flow at the Colac to Forrest Road Bridge on Boundary.

Figure 3. Flows in and Releases to Boundary Creek at Yeodene

- 15 -

FACT: The new observation bores TB1 were drilled 550 metres from Site T1 and begs the question why so far away (see page **49**). Pre 2015 vegetation sites that were 50- 200 metres or so from an observation bore were deemed unsatisfactory and relocated to be in close proximity to observation bores. The TB1 observation bores are at one end of the Big Swamp and the T1 vegetation site is at the other end over 500 m away. T1 and TB1 locations were decided upon post 2014.

FACT: As at March 2016 the galvanised dropper placed in the Big Swamp at the site of the 1997 fire, by Ecology Australia, was still there. If as promised in writing by Southern Rural Water, and if this visit had been written up in 2008, there would have been ample data showing considerable change; decline in vegetation with extensive dead shrubs, trees and other swamp type vegetation. Otway Water books[(36)(39))] discuss and relates these happenings in detail. This swamp had been visited at best as far back as 1986, and at worst, 2008. The main reason given for not writing up the 2008 visit to the Big Swamp is SKM did not have the expertise to comment.[(67)]

For the 2015 survey to state the decline in vegetation conditions at T1 could not be related to groundwater extraction is very difficult to understand when there is a multitude of anecdotal and observable data available saying otherwise. Perhaps the idea that there is not a problem if one does not look for it has been applied to the dilemma of the Big Swamp. Data that should have been included in the 2015 report includes:

- Observation bore Yeo 40 had two trigger points set in the early 2000s. One was that if the watertable in this bore dropped below 158 m AHD then it was stated that Boundary Creek would dry up in the vicinity of the Big Swamp. As the groundwater extraction increased and the watertable dropped, so did the days of no flow in Boundary Creek. The groundwater level seen on page **51** puts the watertable level in Yeo 40 at around 143 m AHD., way below the 158.5m trigger level. The 0.5m tolerance added to the critical level has been exceeded for years.
- As the watertable dropped below the trigger level dramatic changes began to take place, changes that have been observed by local community members.
- The 2016 watertable in Yeo 40 bore is still below the trigger point 6 years after groundwater extraction has stopped.
- At June 2015 the residual drawdown in the Pebble Point aquifer still had 27 metres to recover to a pre extraction level.
- Numerous yearly extractions have far exceeded the Permissible Annual Volume of 4000 ML.
- In 1995 it was calculated that extractions at 4000 ML/year would have impact on the environment within the residual drawdown area of influence.[(116)] The Big Swamp is well inside this influence.
- During dry periods the Artificial Supplementary Flows being released into Boundary Creek disappear into the Big Swamp.
- Even the most casual of observations tell of the horrific impact and vegetation changes that have taken place in the Big Swamp.

- Other perennial streams in the Otway Ranges that source their water from the very same intake area have never been known to cease flowing.

"***The current condition of the GDEs assessed does not suggest that a change in ecosystem function related to groundwater usage has occurred recently. No findings, however, can be derived at this time from the findings at Site T1 – peat swamp.***"[(96)] 2015.

"***The interaction between the borefield and the local watertable at the swamp is currently being monitored via newly installed nested monitoring bores at the swamp.***"[(96)] The location of the Site TB1 observation bores are not within the swamp boundary. The Satellite photograph on, page **49**, shows that these nested bores are over 500 metres and downstream from the vegetation site of T1.
The T1 vegetation transect at the extreme top end of the Big Swamp is not at all representative of the Big Swamp. For a better understanding of what is taking place, the vegetation and bore sites should actually be across the middle reach of the swamp. The vegetation site T1 should be in close proximity to the nested observation bores, not 550 m away. Ideally the data gathering should be located where the Artificial Supplementary Flows disappear into the wetland.

The Jacobs summary of the T1 vegetation site is a classic example of obfuscation (See page **59** for the Summary of the Vegetation Monitoring Report for Site T1. Page **59** should be read in conjunction with the Comment below).

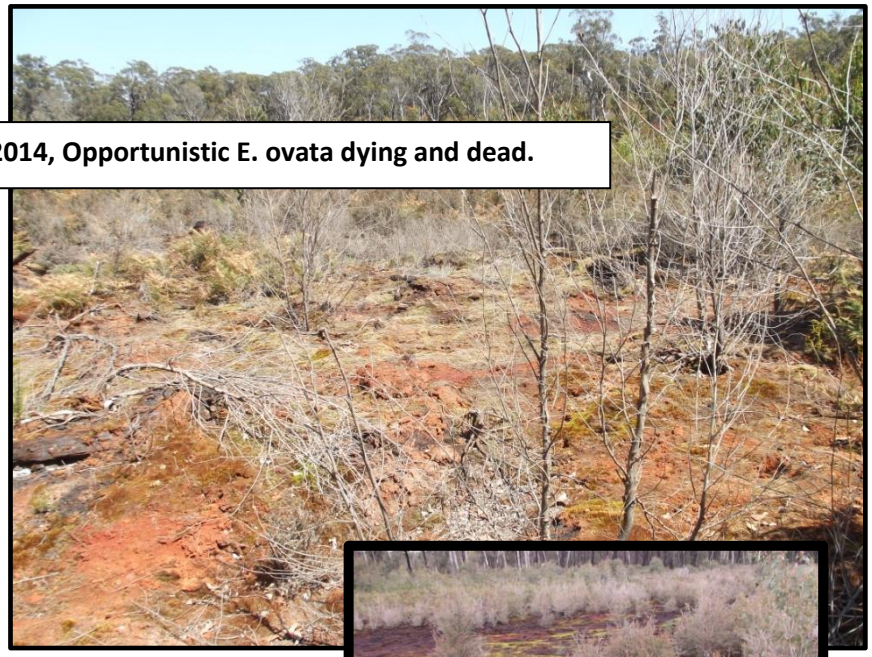
COMMENT on the 2015 Vegetation Monitoring Report for Site T1.

- The first time the Big Swamp caught fire was in 1997, not 1998 as stated by SKM.
- The fact that the Big Swamp had never been known to be dry going as far back as 1912, and because the early 1990s up to 1997 were extremely wet years, the top end of the Big Swamp should never have been dry enough to catch fire in 1997.
- The major known variable bringing this about is extensive groundwater extraction from the Barwon Downs Borefield starting in the 1982-83 drought.
- The 1997-98 fire was only in the very top end of the swamp. The lower end being waterlogged and far too wet.
- This isolated burning area of the Big Swamp was difficult to access and extinguish. Dozers could not enter the swampy area to access hot spots due to the treacherous wet peats lower in the profile. The fire fighters knick named this area Jurassic Park because of the impenetrable vegetation, difficulty to access and the treacherous peats.
- The oxidised peats in this isolated top end area of the Big Swamp began to generate massive amounts of acid that in turn released toxic heavy metals previous locked up in the peat and soil profile. With successive wet winters this toxic mix "crept" downstream through the Big Swamp killing the vegetation as it went. →

- In February 2010 the Big Swamp was on fire again.
  Various theories, including the one that the swamp had smouldered for 12 years, were given for its re-ignition. Whatever the cause, the seat of the 2010 ignition was the site of the 1997 fire.
- The fuel load from dying and dead vegetation created a very difficult to manage wild fire.
- During the course of this fire the entire swamp was burnt and hectares of the surrounding bush went up in flames as well.
- To state that the Big Swamp "***is now recovering***" must be qualified. Invasion by opportunistic vegetation is not a sign of recovery. This vegetation will not survive once the roots hit the toxic layers of acid sulfate soils (see below & pages ***109-111*** for examples of this).
- The boundary trenches were first dug in 2010, one on the east boundary of the fire (3mx3m) and the other to the south (2mx2m). This was to make sure the peat area of the fire was contained within the Big Swamp.
- The transect at Site T1 did not go anywhere near the middle of the swamp.

- The numerous references to burnt and unburnt areas of the Big Swamp are erroneous and especially so for the 2015 transect survey. The entire swamp was burnt to a cinder in the 2010 fire (see pages ***55-58.*** The photo on page **60** is looking back across Site T1).
- The regrowth of Prickly Tea-tree and other regeneration of vegetation noted in this T1 transect has been strongly influenced and is in close proximity to Boundary Creek and has benefitted during dry periods by the Artificial Supplementary Flow releases.
- Half way down the north perimeter of the Big Swamp the Artificial Supplementary Flows disappear from the Boundary Creek bed.
- The regrowth found in the transect at Site T1 is strongly influenced by the Artificial Supplementary Flow releases and the riparian vegetation downstream of Boundary Creek deteriorates as the flow seeps into the surrounding area. .

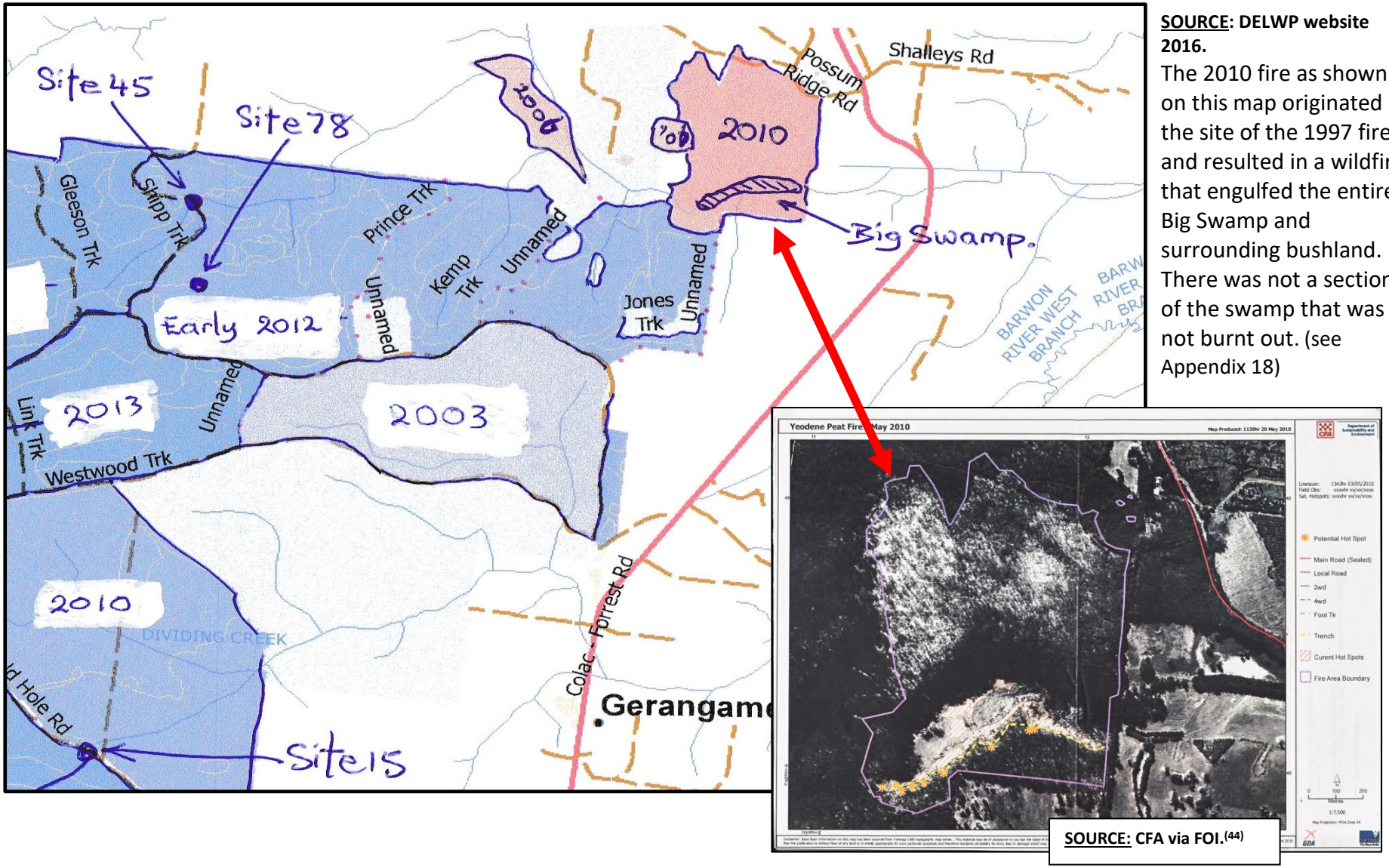
2012, emergent Regeneration starting to die.



2014, Opportunistic E. ovata dying and dead.

2014, at the galvanised dropper site in the Big Swamp, regenerated vegetation dead.

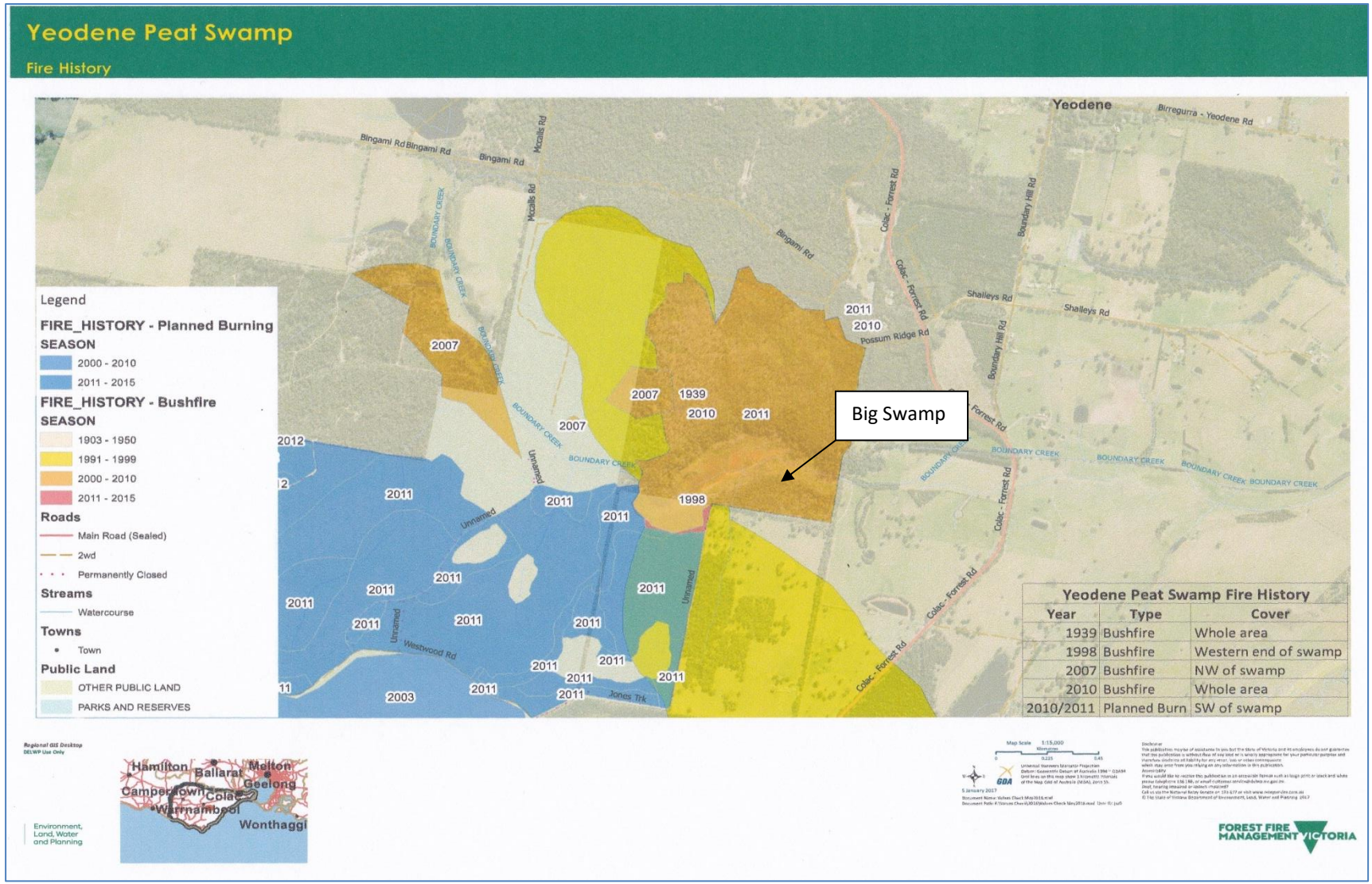
During discussion on the Big Swamp in Jacobs 2016 Integration Report This statement is made "***It is unknown how the fire management response in 2006 altered the key functions of the swamp.***"The 2006 fire was not in the Big Swamp.



SOURCE: CFA via FOI.[44]

SOURCE: DELWP website 2016.

The 2010 fire as shown on this map originated at the site of the 1997 fire and resulted in a wildfire that engulfed the entire Big Swamp and surrounding bushland. There was not a section of the swamp that was not burnt out. (see Appendix 18)



Yeodene Peat Swamp Fire History

Year	Type	Cover
1939	Bushfire	Whole area
1998	Bushfire	Western end of swamp
2007	Bushfire	NW of swamp
2010	Bushfire	Whole area
2010/2011	Planned Burn	SW of swamp

2011, Photographs of the Big Swamp.

Boundary Creek does not dissipate unless there are floods. Dissipation happens at the lower end of the swamp. The bed of the creek hugs the northern boundary of the Big Swamp for the swamp's entire length.(see page 129)

The swamp first caught fire in 1997, then in 1998 and again in 2010. The swamp did not catch fire intermittently between 1998 and 2010.

Studies being conducted by a Southern Cross University student indicate that the swamp is far from in recovery mode.

There was not just one fire front to this fire. It spread in several directions.

The complexity of the Big Swamp is not encapsulated in this description and this lack of understanding can only be gained from tapping into local knowledge learnt over years of visits and observation.

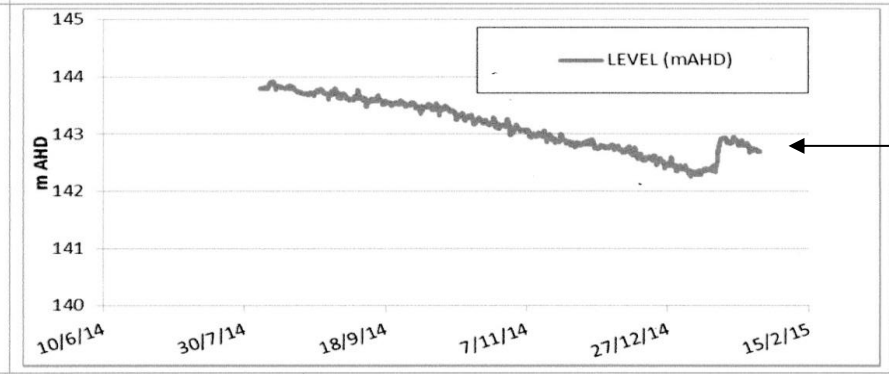
There is also a 3m by 3m trench that was dug along the east boundary of the swamp.

The entire area of the Big Swamp was burnt in 2010. There were no unburnt areas (see next page).

The Big Swamp elevation is above this groundwater level. A 158 m AHD level was established as the critical groundwater level that should be avoided during groundwater extraction. A buffer of 0.5 m was allocated and the trigger was set at 158.5 m. At 144 the swamp will be dry.
Pre extraction the groundwater level was around the 160 m AHD level.

This word should be "generating" as Swamp Gum was never present throughout the swamp.

3.1 Site Summary Tables

Site T1 (new)	Peat Swamp IMPACT, UNCONFINED
Location Description	Located within the Peat Swamp (aka Big Swamp) into which Boundary Creek flows and dissipates before reverting to a channel west of Colac-Forrest Road. The majority of Peat Swamp was burnt intermittently between 1998 and 2010, primarily as a subterranean peat fire, and is now recovering. A large (2m wide x 2m deep) trench runs along the southern edge of Peat Swamp to prevent fire escaping to surrounding areas. The transect is located 5 m north of the trench and extends for 70m at 0 (due north) into the swamp. The transect comprised 14 quadrats encompassing 6 in an unburnt state at the beginning and 8 having been burnt following. Only the latter eight in the burnt areas have been included in the vegetation analysis. The vegetation of the burnt and unburnt sections are described separately below. The transect is located ~ 550 m west of the associated ground water monitoring bore (TB1) whilst trees included in the tree groundwater use study are located within 20 m of the start point of the transect in unburnt areas.
Location Co-ordinates	**START:** E735298, N5743774; **END:** E735248, N5743822
Depth of Groundwater at TB1	
Vegetation Description	**Diversity:** 9 species (4 native, 5 introduced)

Recently burnt section

The burnt areas of T1, toward the middle of the swamp, are characterised by reddish humus and ash at ground level. The above-ground front of the fire is located ~30m north of the transect start. The regenerating vegetation is of low diversity and is dominated by Sphagnum moss at ground level throughout the transect whilst the remaining vegetation is simple, dominated by either Bracken (*Pteridium escultentum*) although this appears stunted, growing to only 50 cm compared to 1 m in unburnt areas, and with many dead and dried plants and with dried leaves on most living plants, or dense Prickly Tea-tree (*Leptospermum continentale*). Species diversity is low with annual weed species such as Sheep Sorrel, Cat's Ear and Sweet Vernal Grass detected in low abundance. Some regenerating Swamp Gum (*Eucalyptus ovata*) is present throughout the affected areas.

Historically burnt section (not included in analyses)

This section, although not included in analyses, was dominated by Bracken with some Swamp Gum and other weedy species present. As per the burnt section, the Bracken showed signs of "burning off" at leaf tips of live plants - some plants had entirely dried.

Vegetation Condition: Poor to moderate – evidence of burnt leaf tips particularly on Bracken could be related to changes in water quality as a result of the fire. Weed invasion has also occurred though may be restricted as the site recovers

Evidence of Change: Fire has occurred in the recent past.

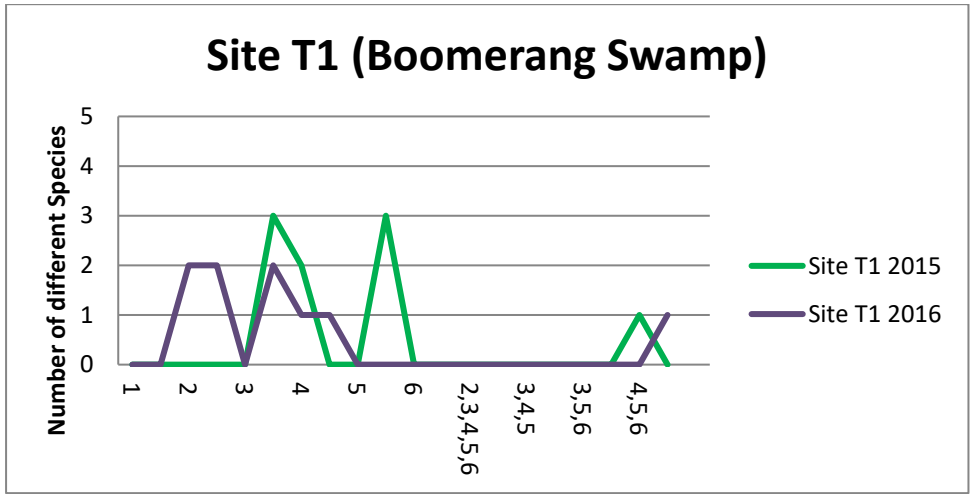
Notes for future monitoring rounds: Particularly note the performance of Sphagnum at this site and the regrowth of Prickly Tea-tree as these dominant species recover from the fire. Also note the changes in the occurrence and performance of weed species.

Site Summary table SOURCE: Page 9, 2015 Jacobs Report.[96]

Looking south east back across transect T1 showing that the whole transect was burnt.

Of the 100 or so sites visited over the years, data collected and recorded for hydrologically sensitive vegetation, the Big Swamp should have been the most visited; its decline and impacts analysed the closest, and conclusive results arrived at. However, the exact opposite has been the result. Despite local community concern and prompting to investigate the circumstances surrounding the Big Swamp's demise since 2007, little to nothing has been done. Given some effort and a will to thoroughly research this site by investigating and compiling local knowledge and available data, an accurate profile and history of the Big Swamp is possible. Groundwater extraction at the Barwon Downs Borefield has had a devastating impact.

Site		1994		2002		2008 Visited				2015		2016 D.Frood		**Natives over all survey periods.**	
		Native	Exotic	Native	Exotic	Native	Exotic			Native	exotic	Native	Exotic		
T1	Total species each survey	-	-	-	-	-	-			4	5	9	1	Species lost...	-
	Same species as previous surveys											1	0	Species at 1 or 2 surveys	-
	New species from previous surveys											8	0	Species at all surveys	-
	Lost Species from previous surveys											3	5	**Total species**	-



There is no doubt that the Big Swamp/T1 has been visited on several occasions. It is also in little doubt that there is overwhelming evidence indicating that the Big Swamp has been dramatically impacted from groundwater extraction at the Barwon Downs Borefield. What is more disturbing and of considerable concern is the manner in which State authorities have avoided an in depth investigation bringing together all of the available data which would accurately, confidently and categorically state the reasons for this swamp's demise - unsustainable groundwater mining.

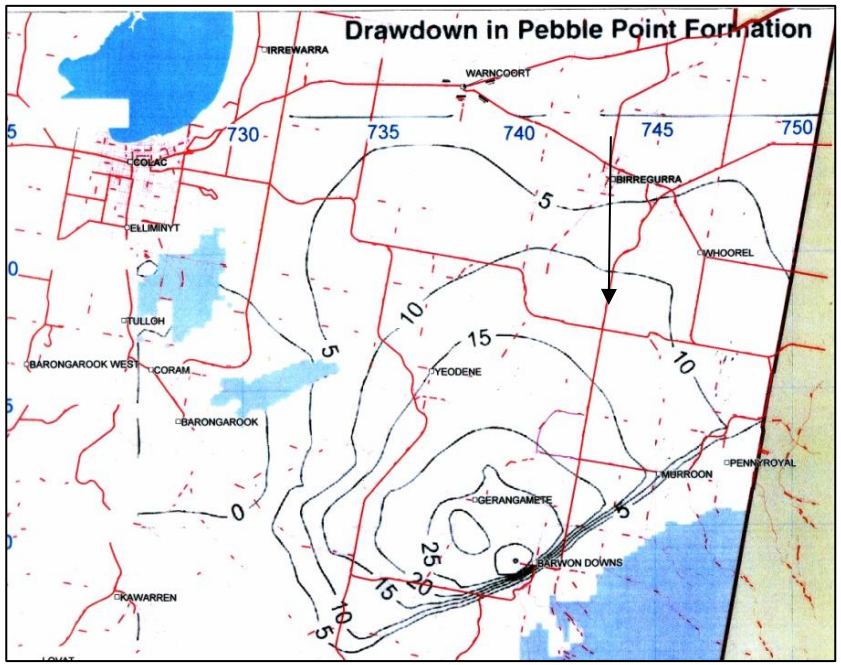
Stream Flow Gauging Station on Boundary Creek.

Site 3(2008) renamed Site T7 in 2015, on a tributary of Ten Mile Creek

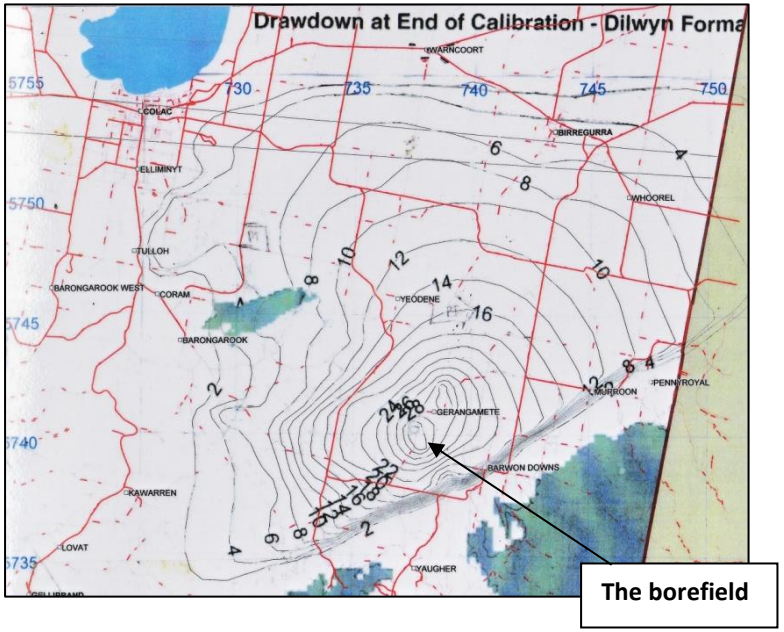
(Site 3 was also called 7.1.C, c 1, in the 2004 groundwater extraction licence conditions & re-numbered T7 when surveyed in 2015).

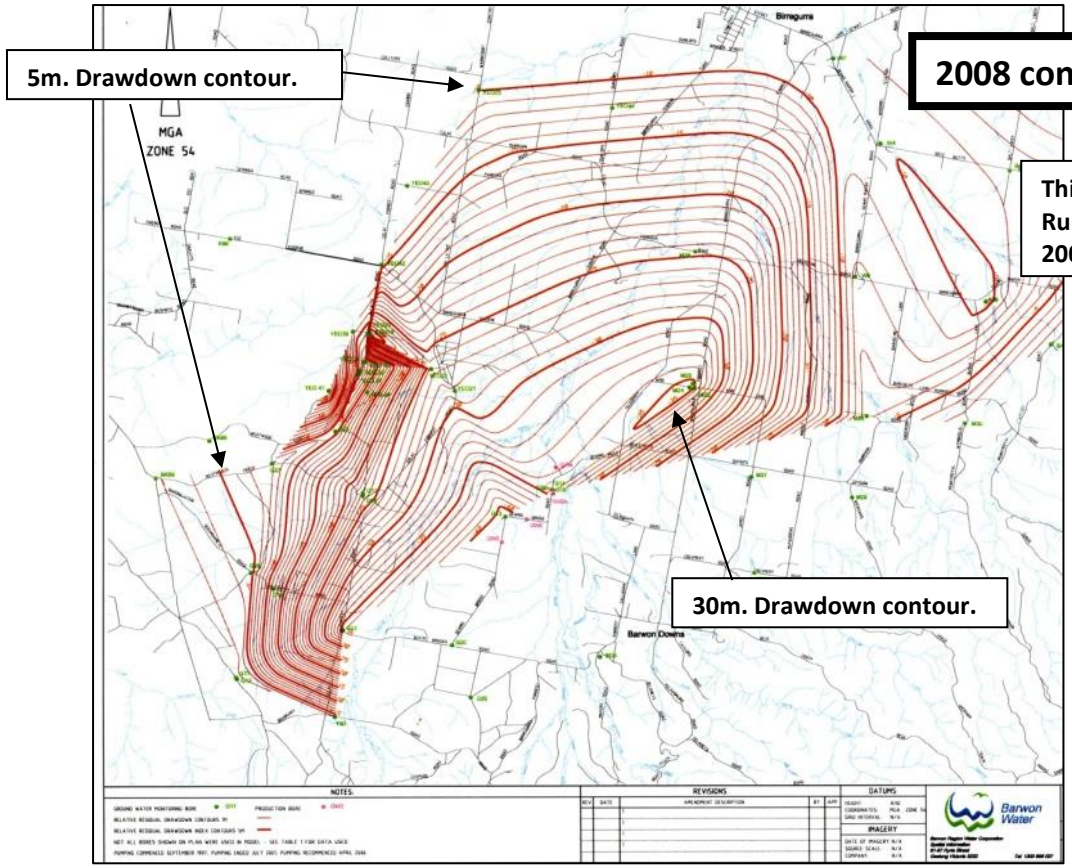
When attempting to include hydrologically sensitive vegetation control sites in the 2004 licence this site was chosen in the adjoining Loves Creek Catchment on a drainage line of Ten Mile Creek, to the west of Boundary Creek. Even at this stage it was obvious from drawdown mapping that the site was under the drawdown influence from the Barwon Downs Borefield, even if ever so slightly. When the 2008 survey was conducted on this drainage line it was found to be a very wet and muddy site with no running water and saturation quickly diminishing on the upslope away from the drainage line; but the soil remained moist. It is a puzzle why one of the tributaries or in fact why the actual creek with flowing water and adjoining riparian vegetation was not chosen. Also, in the comments section of the SKM 2008 report it states this about the Ten Mile Creek Catchment. "***Catchment not subject to groundwater extraction.***"

What this actually means has not been qualified but the site does fall within the area of residual drawdown influence from the groundwater extraction at the Barwon downs Borefield.



Drawdown contours given out during 2004 licence application process.





This partial 2008 contour map was passed by Southern Rural Water as the "official" map for inclusion in the 2007-08 Barwon Downs Borefield report.

There has always been controversy over how far out the influence from the Barwon Downs Borefield extends. A mixture of observable data and modelling has resulted in the maps above, and modelling is notorious for providing the modeller a "get out of goal" excuse. Modelling is only an indication and includes the rider that additional data is required for a more accurate calculation. However, having this uncertainty go on for over 30 years without a concerted effort by Barwon Water to clearly define the drawdown boundaries, and consequently the area of impact from the borefield, is not acceptable. The 2002 drawdown maps above were drawn up before the millennium drought had started. During the drought over 11 000 MLs were extracted per year from the borefield. Observation bore hydrographs down the Site 3 corridor of Ten Mile Creek have continued to decline right up to the present day, suggesting that the drawdown influence from the Barwon Downs Borefield is still impacting through this corridor years after the Millennium Drought has passed.

However, of all the control sites chosen for the 2008 survey this site would have to be regarded as the one site that goes closest to actually being uncompromised by groundwater extraction at Barwon Downs. It was also an appropriate site as it has like vegetation to other previously identified hydrologically sensitive sites in the Boundary Creek area. It must also be remembered that any drawdown effect has continued on even after 6 years of no pumping. The depleted aquifers had only recovered by approximately 13% in 2015. As a consequence it would be

expected that the outer reaches and degree of drawdown influence would have increased considerably. Site 3 is located on the outer reaches of this impact and it would have been extremely interesting to see the condition of the vegetation at the exact same Site 3 in the 2015 survey, especially so after six years of reasonable winters and no groundwater extraction.

Even though Site 3 was the best "control" site in the 2008 survey, it is intriguing that this site had all but been overlooked in the 2008 report write up. Little to no comparison with other sites was made. However, the following comments have been extracted from the report. Some have already been noted, above.

1. Hydrologically this site is water dependent and highly sensitive, requiring constant moisture.
2. Vegetation is in *very good* condition.
3. There are very wet and muddy conditions in the centre drainage line.
4. The presence of water is most likely due to discharge from groundwater.
5. A two metre drop in the water table near this site is not because of groundwater extraction.
6. Data suggested that Site 3 has had no change in water depth since 1984.
7. A general observation was that there was at least some vegetation showing some degree of stress.
8. Ten Mile Creek is in a catchment not subject to groundwater extraction.

Amazingly little else can be found on Site 3 in the SKM 2008 report. With no change in water depth since 1984 Site 3 seemed an ideal site for follow up work.

As this site was found to be in such good condition, not affected by the drought, not affected from groundwater extraction and having no other recognisable influence, one would have expected Site 3 to be used as a true control site with extensive comparison with those other sites surveyed in 2008 showing distinct signs of stress due to moisture loss. Site 3 did not show the characteristics of the other sites that were reported to be under the influence of... "***Moisture changes are occurring at the landscape scale as well as at site scale as a result of the extensive drought period. It was observed universally that indigenous and exotic vegetation has been under severe water stress, particularly at the edges of moisture-sensitive drainage-line vegetation. Moisture stress signs include death of plants and reduced performance of many species, including poor growth of annual and perennial species; premature death of annuals, failure to flower, small crop of flowers or abortion and death of flower buds; reduced seed-set or failure of seed crops; and reduced recruitment. It is probable that almost the entire regional flora has suffered stress in these ways.***" This description was in direct conflict with the very good state of the vegetation recorded at Site 3. However, no discussion or comparison was made of this fact. Site 3 was the best choice as a control site but was never made use of as such. No discussion was entered into querying why Site 3 had not been impacted like so many of the other sites closer to the borefield and inside the cone of depression. What Site 3 did show in 2008 is that sites under the natural influence of the Lower Tertiary Aquifers, without groundwater extraction, should have been in very good condition.

Also, points 2 and 7 above seem to be contradictory. It would be expected that vegetation that is in very good condition would, in general terms, not be showing some degree of stress.

Points 1, 2, 3, 4 and 6 also appear to be contradictory to point 5. Also, how can there be a two metre drop in the water table and yet data suggests no change in water depth since 1984? This is most puzzling and highlights the skimming and offhand manner in which Site 3 was dealt.

Point 8 is the most intriguing of these statements made in SKM's 2008 report. It is a fact that there is no functioning urban extraction borefield in the immediate area in the upper Gellibrand Catchment. However, if this statement means that Site 3 is not influenced by the drawdown effects from the Barwon Downs borefield, this is another story. With all of the resources at Barwon Water's disposal, Barwon Water will not provide up to date residual drawdown contours out to the point of zero influence, and, considering the extensive pumping over the 30 years of the borefield's running period, it is reasonable to assume that the drawdown influence area has increased significantly. It is also not beyond expectation that better data collection should have been undertaken during this period. In some instances it is difficult to make sense of the logic presented in Report 2008.

Impact Within the Area of Residual Drawdown and Impact from Vertical Leakage.

Site 3 is inside the residual drawdown area of influence from the Barwon Downs Borefield. Even if the site has no immediate observable impact it most definitely falls under the influence of vertical leakage that will take some time to materialise.

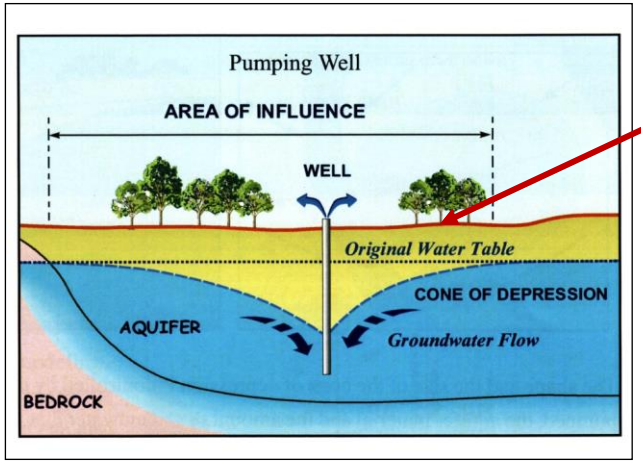


Diagram Source : Centre for Groundwater Studies, Blackwood South Australia.

Site 3 is located within the area of drawdown effect. It will be either directly impacted, or as a consequence of vertical leakage that may take some time to manifest as an observable impact..

The area of drawdown influence does not only affect those areas where the aquifer or its water comes to the surface. This diagram from the Centre for Groundwater Studies highlights this fact. It also shows that an influence takes place right out to the point of zero drawdown. The influence may not be immediately apparent and cannot therefore be dismissed as not taking place. Throughout Report 2008 there appears to be a theme suggesting that drawdown from an aquifer deep underground has little influence on the layers of earth above, including perched swamps, and, that any ongoing impact after groundwater pumping ceases is solely due to environmental influences.

Vertical leakage of water downwards and upwards, from one area of the earth's crust to another is a distinct possibility. Leonard[70] was discussing the certainty of vertical leakage in this very area in 1984. After the extensive evaluation of the Barwon Downs Borefield stress test pump between 1987- and 1991 Witebsky et al [999] wrote this "...***Leakage from the overlaying marls is likely to be the major source of recharge under stressed conditions. The immediately overlaying Narrawaturk Marl is up to 170 m in thickness and grades from silty sands to marl. It has very high storage capacity and within the borefield area is known to contain groundwater of good quality. Under undisturbed conditions an upward vertical, hydraulic gradient exists between the marl and the Lower Tertiary aquifer system and the marl is recharged with groundwater of good quality from below.***" Any investigation or data collection in this regard has been largely ignored right up to 2016.

Page 31 of Report 2008 discusses the possibility of vertical leakage and states that at this stage there is no evidence that this has occurred. The reason for this lack of evidence is that only 3 of the 61 regional observation bores used in Report 2008 were monitoring this possibility. The principle of vertical leakage has been a reality for decades and it seems unbelievable that scant data has been collected over the 34 year period of groundwater pumping at Barwon Downs, especially when it was stated in 1995 that vertical leakage into the depleted aquifer would be the major source of recharge. If this data had been collected it would have provided an accurate assessment of the degree of vertical leakage that has taken place. Just because data does not exist doesn't automatically rule out that vertical leakage is taking place. Report 2008 recommends that mapping and this type of data collection be put into place. Why this has not already been done decades ago is most baffling(see pages **102-103**).

Deplete a deep water aquifer and the confining aquitard above the depleted aquifer will start to leak downwards. This leakage will be slow but persistent and layers above this water depleting aquitard will then also begin to leak down to replace water in the aquitard. Because this process is so slow impacts at the surface may not be apparent for some considerable time. In fact impacts may materialise decades after groundwater extraction has ceased.

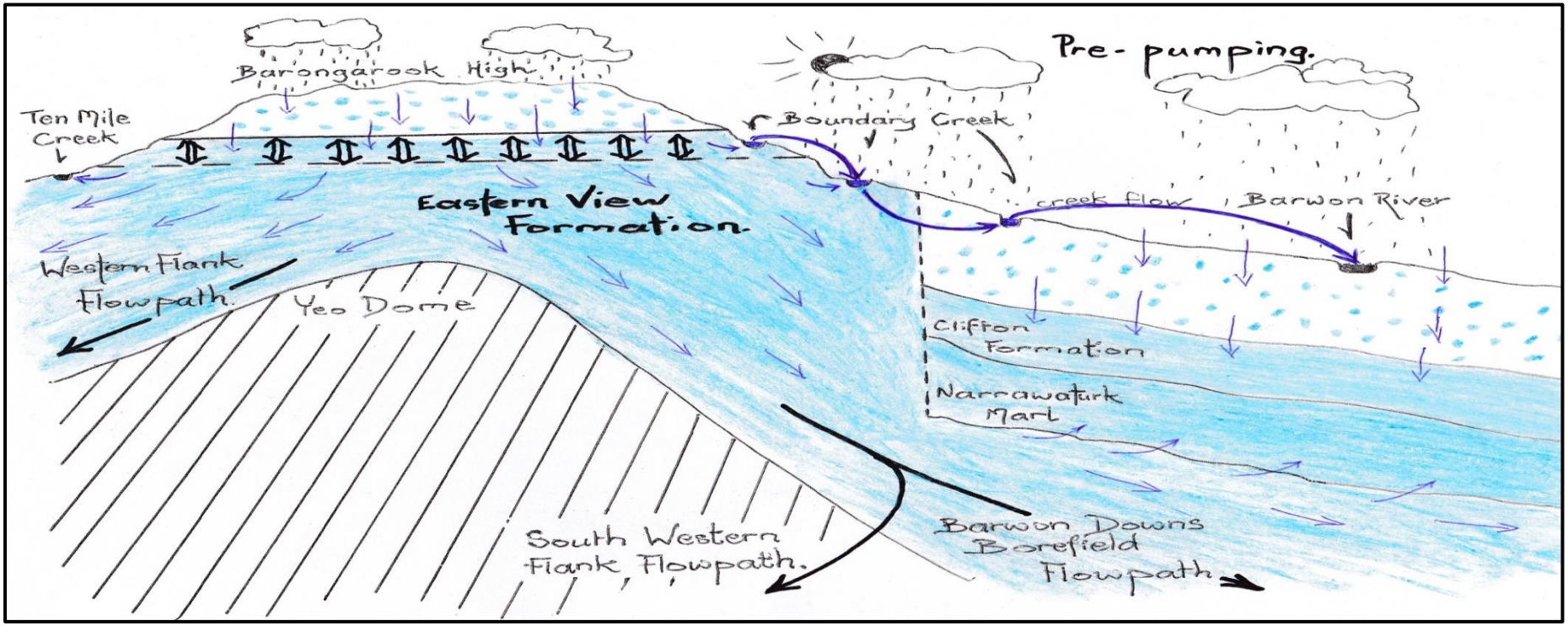
Vertical Leakage from One Layer to Another.

Sky – rainfall soaks into the ground	A certain amount of rain falling soaks into the ground. SKM Report 2008 suggest between 23-28% soaks into the unconfined aquifer in the Barongarook High Area.
Unsaturated zone	In the gaps between particles of soil this zone contains both air and water.
Aquitard	An aquitard is a confining bed that can be saturated and allows water to move vertically through it. This movement is generally quite slow and can be in an upward or downward direction. Deplete the water in the aquifer below and water out of this confining layer will begin to leak downwards.
Confined Aquifer Aquifer depleted.	These aquifers can be recharged where they are exposed at the surface and or from leaking 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.

When a confined aquifer is full it forces water up into the layers above and over time reaches a state of relative equilibrium. The unsaturated zone at the surface oscillates between being relatively dry during summer and relatively saturated during winter. However this Dynamic Equilibrium Water Level Zone can be upset with regular and sustained amounts of groundwater extraction. As an aquifer is depleted the phenomenon of vertical leakage downwards takes place. Over an extended period the aquitard above the confined aquifer begins to leak downwards and dry out and causes a similar downwards leakage effect to take place all the way to 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, the probability of vertical leakage is all but certain. It is confounding why this has not been discussed in Report 2008. It is even more disturbing that vertical leakage data has not been collected over the years. Site 3 falls within a downwards trending vertical leakage impact area. Impacts

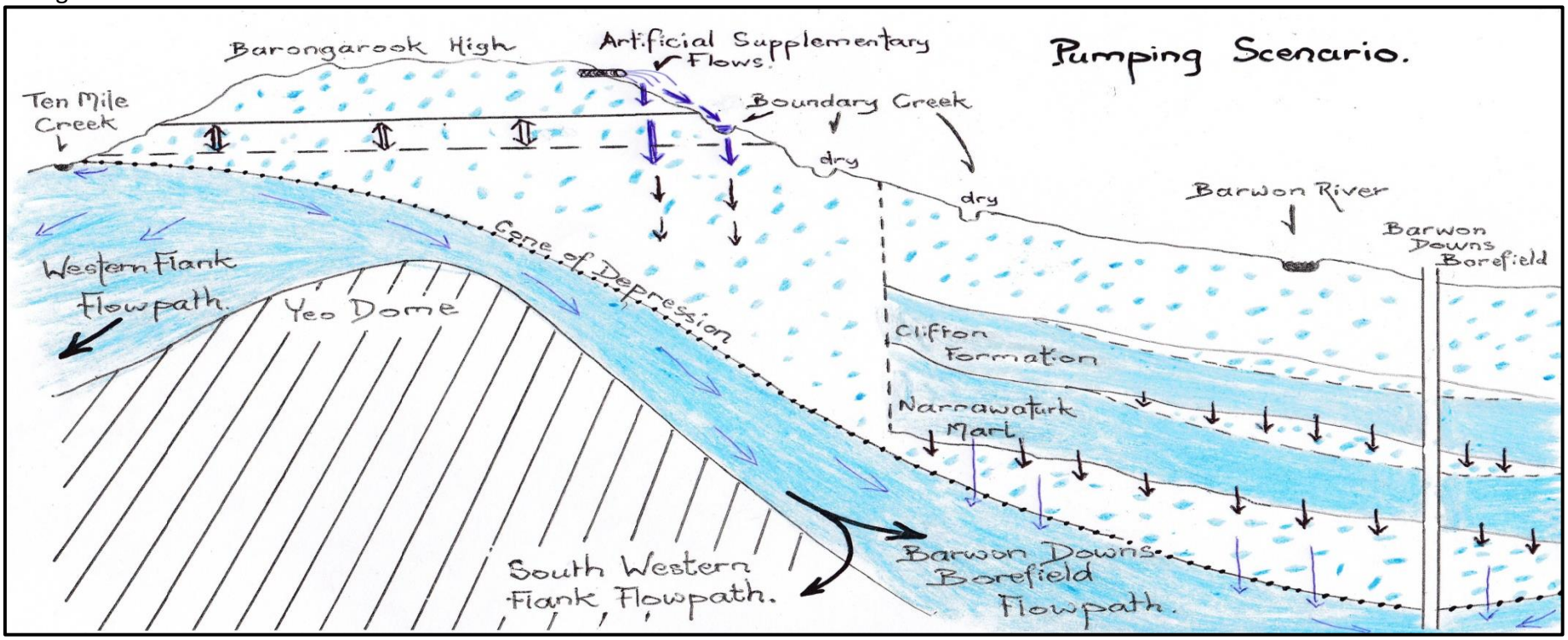
from vertical downward leakage may take years to be realised at the surface, years after pumping ceases. This is one reason why Site 3 should have been kept as a site for ongoing research.

The following two conceptualisation diagrams (this page & page 70) show the drawdown and vertical leakage processes.



This conceptualisation figure shows the Lower Tertiary Aquifers under natural conditions pre groundwater extraction. During normal weather patterns the Dynamic Equilibrium Water Level Zone (see page **35**) would oscillate up and down. During dry or drought periods the Dynamic Equilibrium Water Level Zone would drop and then rise during recharge events.
Under natural conditions the Narawaturk Marl would have water driven up into it from the pressurised aquifers below. In turn water would be forced up into the bottom of the Clifton and perched aquifer formations. Infiltration across the system would also come from rainfall.

The functioning of this system would have evolved over eons of time and ecosystems would have adapted accordingly, reaching a relatively stable equilibrium where discharge from the system equalled recharge into the system. The ecosystems would have adapted to the natural Dynamic Equilibrium Water Level Zone variations. However, if water extraction from the Lower Tertiary Aquifers was greater than the recharging capacity of the system then changes would take place. The greater the difference between recharge and extraction the greater the changes.



This cross section highlights some of the changes that take place when an aquifer system is drawdown faster than the natural processes can recharge this system.

Groundwater extraction causes the water table level to fall way below the Dynamic Equilibrium Water Level Zone; Boundary Creek stops running; water from the Narawaturk Marl begins to leak downwards to fill the dewatered space and the Clifton Formation aquifer begins to leak downwards to fill the leaking Narawaturk Marl. Perched aquifers form part of this system and fall under the same downwards vertical leakage influences.

As the cone of depression spreads, water from further and further out is sucked into the void that is left from the groundwater extraction.

40 native species and 6 exotic species were identified at Site 3 in 2008. A taxa of state significance was found and one at a nationally significant level. Vegetation was reported as in very good condition with a Leptospermum lanigerum overstorey at 5-6 metres high. The vegetation at the site was water dependent and highly sensitive, requiring constant moisture. This site was included as a control site in the 2004 groundwater extraction licence conditions and to all appearances seemed to be outside any direct influence from the borefield. The 2008 surveyed seemed to confirm this. All excellent reasons why this site should have been one of the 14 "new" sites chosen for the 2015 survey. Site 3 was moved further from the borefield influence and renamed T7.

It is interesting to return to the fact that little comparison was made in 2008 between Site 3 and those sites accepted as being within the influence of the borefield drawdown. The 2008 report spoke of regional flora stress but did not draw any comparisons with the "control" Site 3 that was reported as in very good condition. The term "*regional flora stress*" and its boundaries need to be clearly defined.

In 2015 Jacobs renamed Site 3 as Site T7. In one part of the report it states that T7 is an existing site. In another section it states that T7 has been relocated 200 metres from the 2008 Site 3.
Site T7 had 27 native species identified and 2 exotic species. 12 of the natives were the same as in 2008, with 15 different native species identified and 28 species lost. Quite a significant difference in vegetation species identified between the two surveys.

The table below on page **73** shows those sites from the 1994, 2002, 2008 and 2015 vegetation surveys that identified 47 or more species. This table highlights the rich diversity of vegetation found at sites in the 1994 survey. Such richness was not found again until the 2008 survey when the Ten Mile Creek site, Site 3, on the fringe of the drawdown impact area, was chosen. This site was chosen in an effort to have a control site outside the influence of the Barwon Downs Borefield and it would appear to be a relatively good choice.

If the T 7 site was in fact situated exactly at the 2008 Site 3 it could be argued that the loss and change of 43 species by 2015 is very significant, and that the site appears to be degrading the same way as other sites identified closer to the borefield. In 2008 the selection of Site 3 seemed

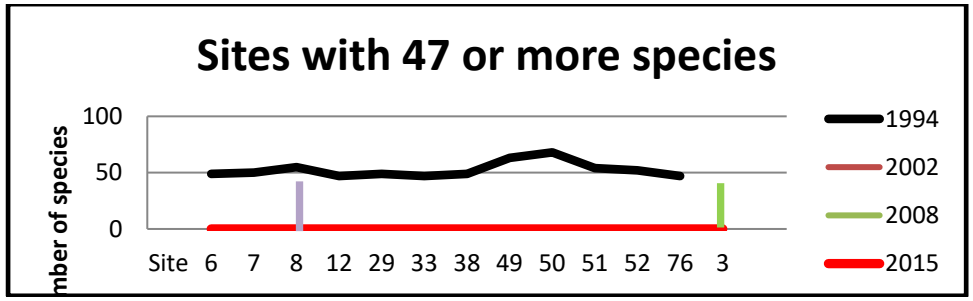
to be ideal for monitoring hydrologically sensitive vegetation, especially when there was a wide range of water dependent species and the *water table was right at the surface*. The 2008 report states "***Table 4 suggests Site 3 has had no change in water table depth since 1984, with the water table remaining at the surface.***" If the change of 200 metres from Site 3 to Site T7 was made to have a water table observation bore nearby, or to facilitate the drilling of a new bore, the arguments against this is, there was already an observation bore within 350 metres of Site 3, and, the water table being at the surface anyway was already observable. Also, a complete contradiction to the argument of 300 metres being too far away is seen when Jacobs drilled a new observation bore network for Site T1, 550 metres away from the survey site (see, page 49).

Sites Surveyed since 1993 that had a total of 47 or more species identified.

Of the 100 or more sites surveyed these 13 sites had 47 or more species identified.

Site Number	47 or more Species identified in 1994	47 or more Species identified in 2002	47 or more Species identified in 2008	47 or more Species identified in 2015
6	49			
7	50			
8	55	54		
12	47			
29	49			
33	47			
38	49			
49	63			
50	68			
51	54			
52	52			
76	47			
3 (Started in2008)	NA	NA	47	

(Site 3 was changed to Site T7 in 2015 and was reported as being at an existing site. However, the species list fell short of 47.)



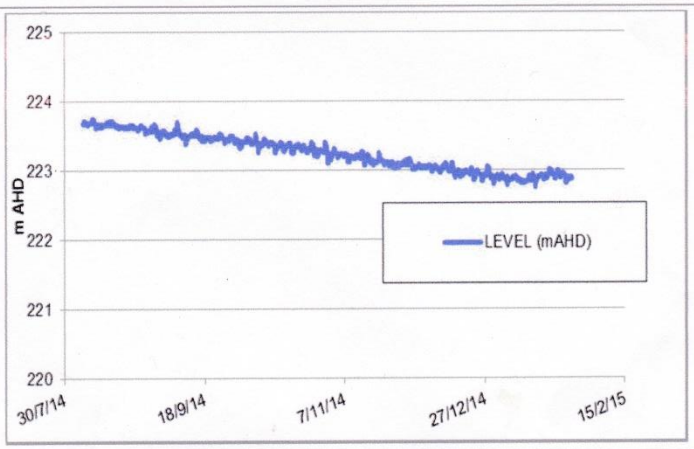
It would appear to be significant that within 8 years the only vegetation site surveyed in 1994 with 47 species was at Site 8. When Site 3 was introduced in 2008 it was the only one of the sites surveyed that had 47 species identified. By 2015 Site 3 or T7 had 29. Water dependent species decline and a shift to vegetation species requiring drier conditions is taking place.

T 7 existing site. Presumably Site 3.

Vegetation Monitoring Report

JACOBS

Site 3 in 2008 on tributary Ten Mile Creek, 2015 Site T7.

Site T7 (existing)	Swamp Scrub – off Robinson Road REFERENCE, UNCONFINED
Location Description	Located at valley of an un-named tributary of Ten Mile Creek on an access track running off Robinson Road. The site is located on the western side of the track heading due west from the start location. The start of the transect is located ~ 25 north west of the monitoring bore TB7 and is close to the Old Beechy Trail which is located approximately 50 m to the north.
Location Co-ordinates	**START:** E727517, N5742297; **END:** E727483, N5742294
Depth of Groundwater at TB7	

Vegetation Description	**Diversity:** 30 species (28 native, 2 introduced)

With a largely absent tree layer other than Narrow-leaf Peppermint (*Eucalyptus radiata subsp. radiata*) to 15 m at the end of the transect and the edge of the GDE, the vegetation was dominated by a dense fern layer over dense cover of Scented Paperbark (*Melaleuca squarrosa*) and understorey dominated by large sedges (*Lepidosperma elatius* and *Gahnia sieberii*), ferns (*Blechnum nudum* and *Pteridium esculentum*) and scrambling grasses (*Tetrarrhena juncea* and *Poa tenera*). A number of terrestrial species but can opportunistically occur in when soil conditions are not too damp were present that are more generally found in nearby (but still damp) terrestrial ecosystems.

Vegetation Condition: In good condition – no evidence of dieback observed and recruitment evident

Evidence of Change: None observed

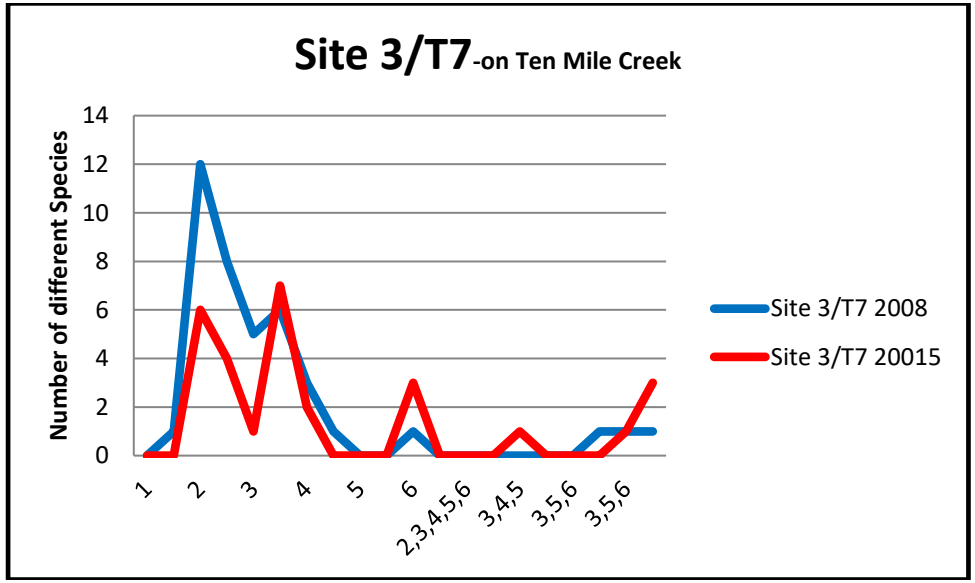
Notes for future monitoring rounds: Check the ongoing persistence of the ground ferns in particular as these could be especially vulnerable to changes in groundwater availability at the site.

Comparison to 2008

The site chosen for the transect is some 200m from Site 3 assessed in the 2008 study. The location was changed to better relate the site to the bore location. The species present are similar but the site does not have the surface water noted in the reports. The density of the shrub layer is decreased and the cover of ferns increased at the current transect The current site is downstream (although there is no defined channel) from Site 3.

200 metres from Site 3. The T 7 observation site on Map Five, page **28**, would appear to be still over 200 metres from the vegetation site. The majority of the 2015 vegetation survey sites are right next to the observation bore.

Site						2008				2015				**Natives over all survey periods.**	
						Native	Exotic			Native	exotic				
3	Total species each survey					40	6			27	2			Species lost...	28
T7	Same species as previous surveys									12	0			Species observed once	43
	New species from previous surveys									15	2			Species both surveys	12
	Lost Species from previous surveys									28	0			**Total species**	55



This graph shows a decline in water dependent species and a definite shift towards vegetation requiring drier conditions.

If T7 is in fact the existing Site 3 it is understandable why an effort has been made to have it moved and identified at a non comparable site. The shift and decline in vegetation as depicted in this graph supports the notion of a spreading area of impact from groundwater extraction at the Barwon Downs Borefield.

Site 78/T3 Boomerang Swamp (See Appendix 11, page167 for a species lists.)

(All eighty pages of Otway Water Book 9 discusses the lack of scientific rigour and the deplorable manner applied to the investigation and long term "wellbeing" of the Boomerang Swamp – 1994/2002 Sites 78 and 79.)

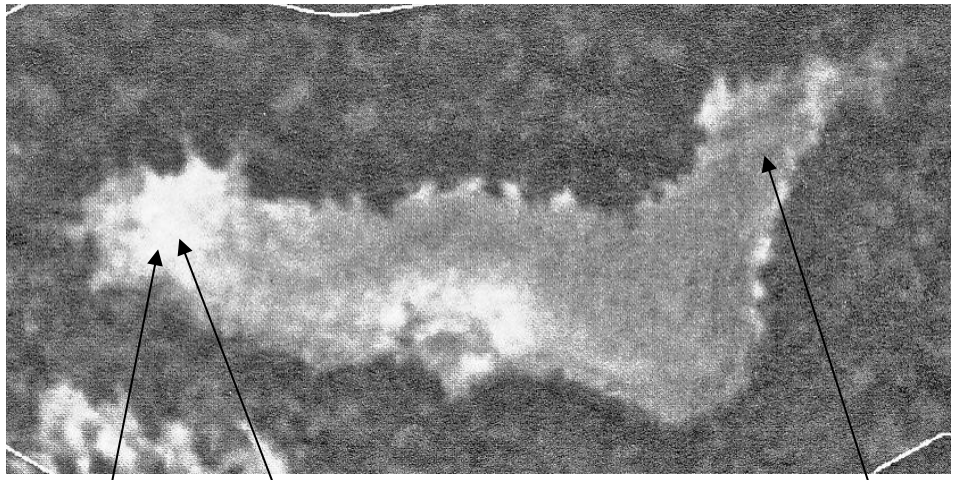
Sites 78 and 79 were surveyed and reported on in 1994 and 2002 as a Community 6.0 Wetland (category 1) of very high vegetation quality and of State significance. Site 78 is at the western end of the swamp while Site 79 is at the north eastern end. Galvanised droppers were placed at these sites in 2008 but not reported on.

Site 78, at the west end of the swamp.

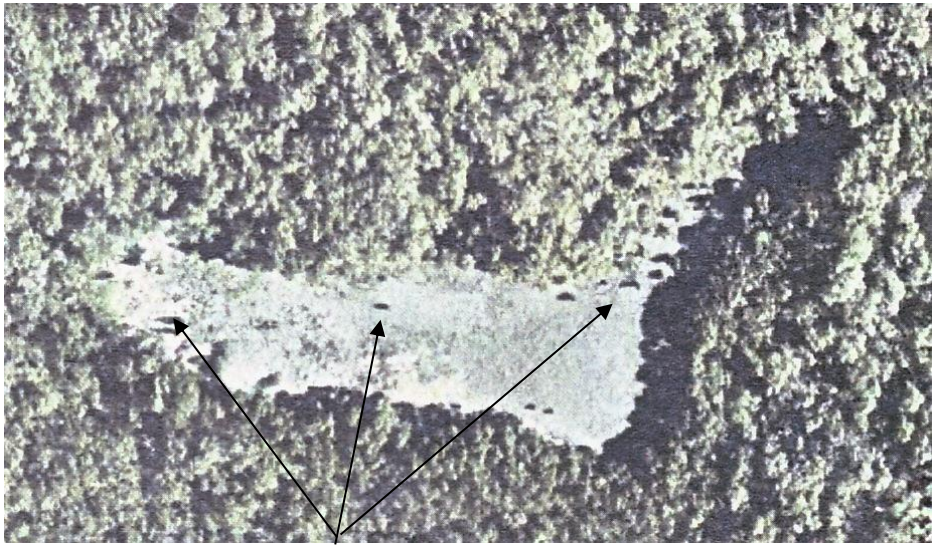
Gal. dropper at Site 79, looking south west through the swamp in 2009.

Site 79, in the north east corner.

On page **88** the galvanised dropper at Site 79 shows the height water had risen to in the 2010 floods. The corrosive effects of the water generated in this swamp after a two month period is quite evident. The photograph on page **77** shows the effect of subsequent higher floodings.



The Boomerang Swamp in 1947.



Boomerang Swamp in 2007 showing intrusion into the swamp by trees.

Site 78 in 2012

When the millennium drought broke late in September 2010 the Boomerang Swamp was flooded for the first time in many years. This picture was taken at Site 78 in October 2012 looking west into Site T3. Boomerang Swamp has been flooded on several occasions since the end of the drought. The swamp was dry again when visited in March 2016.

Site 79 looking south through the swamp.

This is the galvanised dropper at Site 78 on 16-04-2016.

The droppers were placed at Sites 78 and 79 in 2008. Their unrusted appearance remained the same in a dry swamp with no evidence of rusting (see pages 76, 83 and 84), until the floods of late September 2010. By November when the water subsided the droppers had suffered substantial corrosion.

This photograph and the one on page 77 above, show the evidence of Boomerang Swamp having flooded at least one more time since November 2010 and at a higher level as the corrosion has doubled in height up the galvanised dropper.

Site 78, 1994 (Boomerang Swamp).

Two sites 78 and 79, were visited by Ecology Australia in 1994. 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.[93]

The swamp was a "... ***rare example of a swamp in an unmodified catchment and so the site of significance includes the catchment***."[93]

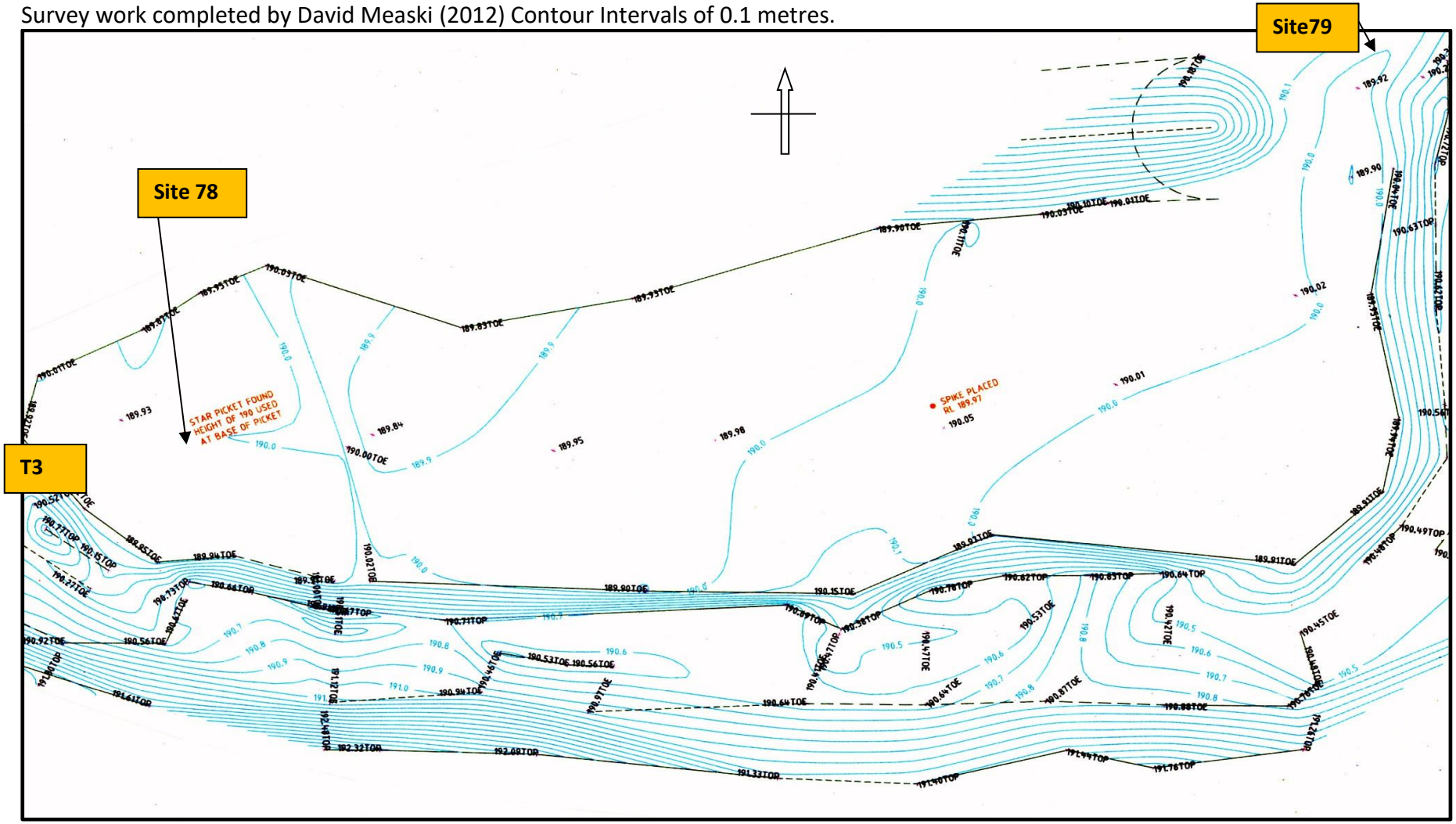
Carr and Muir[93] of Ecology Australia, described this swamp as "... ***little free water over most of surface but soil permanently wet and boggy, northern end has the deepest water, c. 5-10 cm; water table presumed to be at or near surface – relationship between water table and surface topography needs 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[93] 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).***"

To gain a better understanding of the swamp and surrounding topography layout David Measki conducted a survey of the site. The swamp itself was found to be relatively flat with a slight sloping gradient towards the outlet in the north east corner. The northern boundary of the swamp rose dramatically whereas the western, southern and eastern sides had a slightly raised lip to another relatively flat area with a totally different vegetation type (see pages **81** and **89-93**).

Survey work completed by David Measki (2012) Contour Intervals of 0.1 metres.



Around the west, south and east verges of the Boomerang Swamp there is a slight uplift to the profile. Above this there is another relatively flat secondary wetland before another uplift out of the swampy area. To the north the uplift is severe and dramatic.

These photographs shows this uplift onto another tier that was most likely seasonally inundated. (Photos taken October after the fuel reduction burn early in 2012)

Site 78, 2001 (Boomerang Swamp).

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.***"[95]
Barwon Water required a brief report consisting of what was found and a comparison with the 1994 survey results.

Carr[95] 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.

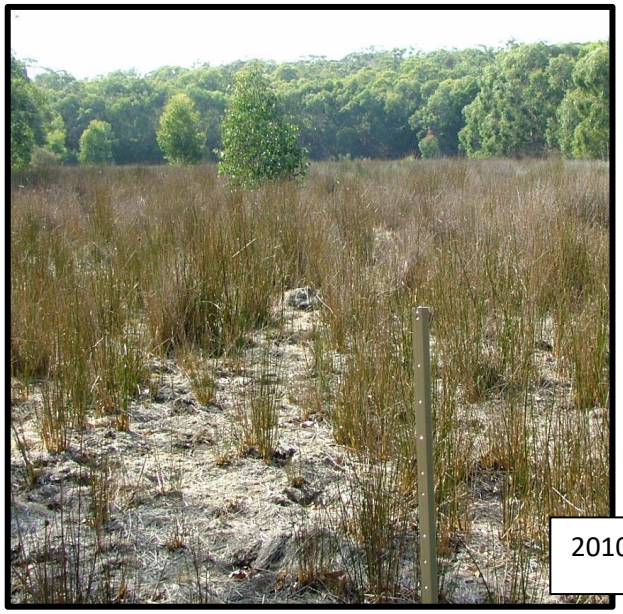
> "***Changes to vegetation floristic composition and structure in two high-quality essentially pristine, undisturbed (by exogenous disturbance factors) environments of apparently closed catchments – swamps containing sedge dominant wetlands – Sites 46, 78 and 79.***"

Carr[95]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[95] found the "***very rare Fine Twig-sedge***" sites at Boomerang Swamp had...

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



2010.

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.

Both sites were visited in 2008 and galvanised droppers were placed marking the sites, but no report of this 2008 visit is available.

Photograph looking back in a southerly direction past Site 79. Note the colonisation of eucalyptus trees.

In 2012 a fuel reduction burn was conducted in the area and the margins and some of the dry swamp was burnt.

Looking south from Site 79 taken after the fuel reduction burn.

Site T3, 2015 (Boomerang Swamp).

In 2015 Site 78 was re-visited. A site approximately 26 metres to the west and 141 metres to the south of Site 78 was chosen for the 2015 study. This site was recorded as T3.

Because of the extremely close proximity to Site 78, it is difficult to understand why this was named as a new site.

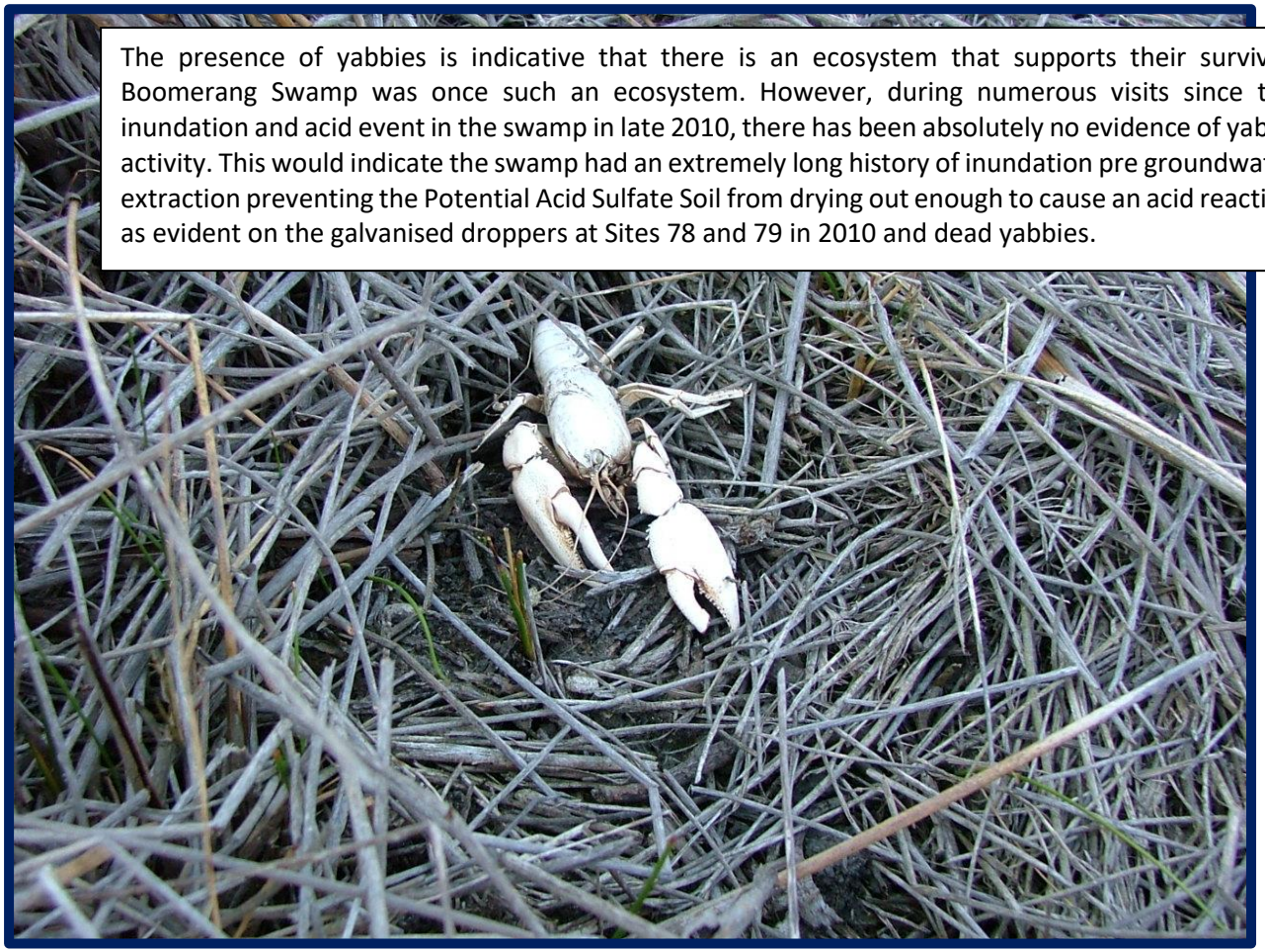
In the 2015 study T3 was classed as a new site at a perched swamp. During the renewal process of the 12600 ML/year extraction licence SKM stated in 2002 that the Boomerang Swamp did in fact sit on a perched aquifer and this allowed Barwon Water to abdicate any responsibility to "care" for this swamp, stating there was no connection to the aquifer Barwon Water was pumping from. As a result draft licence conditions protecting this swamp were "dumped." However six years later, in the 2008 survey, SKM stated that there was no evidence or data that supported a notion that perched swamps existed in this area.

The 2015 Vegetation Monitoring Report has these things to say about Site T3.

1. Eleven species were identified and all were classified as groundwater dependent.
2. It is located on an unnamed swamp with standing water across a 1.2 hectare area.
3. The swamp drains to the north east.
4. The western end of the swamp was chosen as "***any potential changes are more likely to be detected at the upper end***" of the swamp.
5. The transect had standing water to 35 cm.
6. Twig sedges and Large rush to 1.5 m dominated the wetland.
7. Aquatic grasses present throughout.
8. Swamp Gum occasionally encroaching on the edges.
9. Trees tended to be small and prone to falling – potentially due to water logging.
10. Logs were common throughout the transect.
11. Low diversity of vegetation.
12. Swamp appears to be in good condition.
13. Little evidence of die-back.
14. No evidence of change.
15. The swamp is most likely linked to a perched aquifer.
16. Could be an interesting reference site for future monitoring (Site T3 is named in the modified licence conditions of 2012-14 and ***must*** be monitored in future surveys).

One of SKM's pictures taken at the Site T3 had this caption underneath.
"***Range of lifeforms present within the water throughout the transect.***" No faunal lifeforms could be seen in the photograph. Of the 14 sites in this SKM 2015 study and of the 53 pictures taken, T3 was the only site with a picture that made note of water lifeforms. One other picture made reference to a yabby hole at SiteT2. If this T3 reference is being made in regard to fauna there are two points that are most curious. One being why is this the only reference being made to lifeforms in water found at a site, and the other is that throughout many of my visits to the

Boomerang Swamp the only evidence of fauna lifeforms at T3 were multitudes of bleached yabby skeletons scattered throughout the swamp in 2009.



The presence of yabbies is indicative that there is an ecosystem that supports their survival. Boomerang Swamp was once such an ecosystem. However, during numerous visits since the inundation and acid event in the swamp in late 2010, there has been absolutely no evidence of yabby activity. This would indicate the swamp had an extremely long history of inundation pre groundwater extraction preventing the Potential Acid Sulfate Soil from drying out enough to cause an acid reaction as evident on the galvanised droppers at Sites 78 and 79 in 2010 and dead yabbies.

Beside the testing and evidence of borderline Potential Acid Sulfate Soils present in the swamp,[67] this picture of the galvanised dropper at Site 79 after two months of inundation in 2010, indicates the toxicity that was created in the water over a short period.

In the actual swamp there are no logs. In the second tier there is considerable woody vegetation. Any encroachment from trees into the swamp has been of recent times (see pages **76- 78, 83- 86**). Other than numerous trees that have colonised the margins Boomerang swamp has been free of woody vegetation for an extremely long period if not for ever.

Boomerang Swamp after the 2012 burn.

Boomerang Swamp early 2010.

For the 2015 report to state no evidence of change, is an interesting comment. This whole area in and around the Boomerang Swam was fuel reduced through controlled burning in 2012. The SKM report makes no mention of this burn and the likely changes and impact it has caused on vegetation composition.

This 2012 photograph was taken looking back into the second tier from the swamp after the fuel reduction burn (see fire map page **56**). Evidence of this burn is still apparent to this day.

This photo was taken looking north back from the tier into Boomerang Swamp.

Logs may have been common throughout the T3 transect, and when reading the full description of T3 an impression is given that logs were common throughout the swamp. This is not the case.

This snap is looking east across Site T3 towards Site 78 and is scattered with logs.

However, this photograph taken from Site 78 looking in the same direction, gives no such impression.

For the 2015 SKM report to state that the overall condition of the swamp looked to be in good condition and with no evidence of change is quite amazing. Since the Ecology Australia survey in 1994 Boomerang Swamp has undergone considerable change. It has been dry on numerous occasions; corrosion of the galvanised droppers has taken placed during inundation indicating acid events; the area has been intensively burnt and invasion by opportunistic woody vegetation has taken place and this invading vegetation shows signs of obvious stress. Of the 14 sites visited in the 2015 survey, T3 was the only site reported as having no opportunistic vegetation found. Strange.

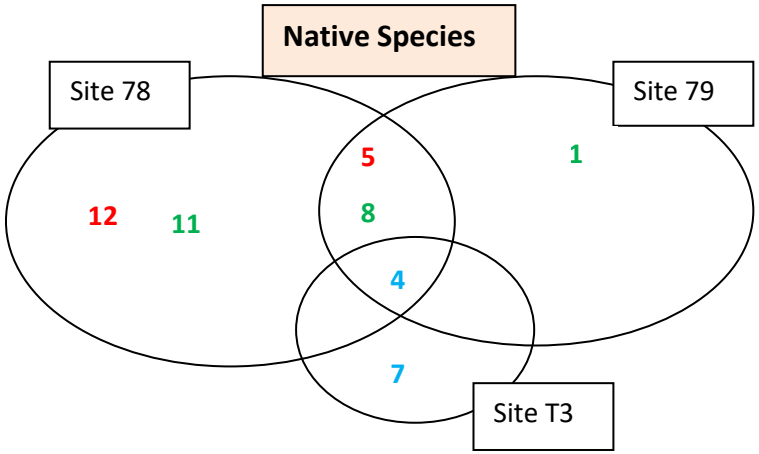
During my March 2016 visit to Boomerang Swamp the only sign of fauna lifeforms in the swamp location was one lizard and bush rat diggings. These were observed on the very margin of the swamp.

Once again in 2015, SKM put forward the notion that the Boomerang Swamp sits on a perched swamp. When Ecology Australia re-surveyed Sites 78 and 79 in 2002, the changes since the 1994 survey were so dramatic they prompted the drawing up of draft licence conditions that were designed to protect this Boomerang Swamp. However, SKM advised that this swamp was a perched swamp and had nothing to do with the extraction of groundwater at the Barwon Downs Borefield even though it was within the area of residual drawdown influence and subject to vertical leakage. The protective conditions for Boomerang Swamp were dropped from the 2004 licence. But, in 2008 SKM stated there was no data to support any notion of perched swamps in the area of drawdown influence including the Boomerang Swamp. Because of the 2015 assertion that the Boomerang Swamp was indeed sitting on a perched swamp and to get a better understanding of the connections with groundwater an observation bore was reported as being drilled in close proximity with Site T3. However, the observation bore associated with T3 was drilled over 200 m away and at an elevation many metres above the swamp. In layman terms this bore is no where near Site T3 and once again begs the question why so far away when some of the 2008 licence conditios sites were no longer applicable because they were too far away from an observation bore. Remebering also that the T1 observation bore was drilled over 550m away and further confounds some of these decisions and justifications.

In 1994 there were 17 native and one exoctic species found at Site 78. In 2002 there were 19 native species surveyed and 2 exoctic. Ten of them were different native species and one different exoctic. Seven native species found in 1994 were no longer found. Quite a dramatic change. It is interesting to compare the species surveyed at Site 79 with Site 78 during these periods. In 1994 Site 79 had 5 native species also found at Site 78. By 2002 one species, the Southern Water-ribbons, had disappeared and five different native species were surveyed. Of these 5 at least two of them can be regarded as opportunistic requiring drier conditions to survive – Eucalyptus ovata and Eucalyptus viminalis – thus the numerous trees arounds Site 79 as seen on page **84**.

Site T3 in contrast, supposedly a new site, when surveyed was found to have no opportunistic species; 11 groundwater dependent natives and no exoctics. Jacobs maintains species fitting into the categories 1-4 are groundwater depenedent. Six of the native species had not been surveyed at either Site 78 or 79.

Fifteen native species and one exoctic at Site 78 in 2002 were not found at T3 in 2015.



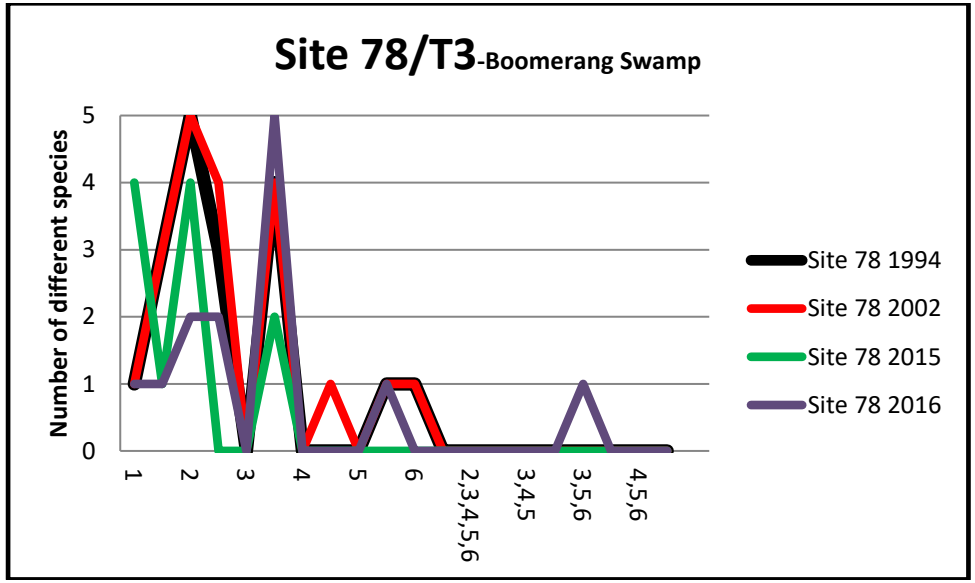
Native Species identified in the **1994** survey.

Native Species identified in the **2002** survey.

Native Species identified in the **2015** survey.

The overlap of the 2015 species shown with Sites 78 and 79 only indicates a common species identified earlier at Site 78 or Site 79. Sites 78 and 79 were not surveyed in 2015.

Site		1994		2002		2008Visited but no records				2015		2016		**Natives over all survey periods.**	
		Native	Exotic	Native	Exotic					Native	exotic	Native	Exotic		
78	Total species each survey	17	1	19	2	-	-			11	0	11	3	Species lost...	26
T3	Same species as previous surveys			9	1					5	0	7	2	Species at 1 or 2 surveys	33
	New species from previous surveys			10	1					6	0	4	1	Species at all surveys	4
	Lost Species from previous surveys			8	0					20	2	26	0	**Total species**	37

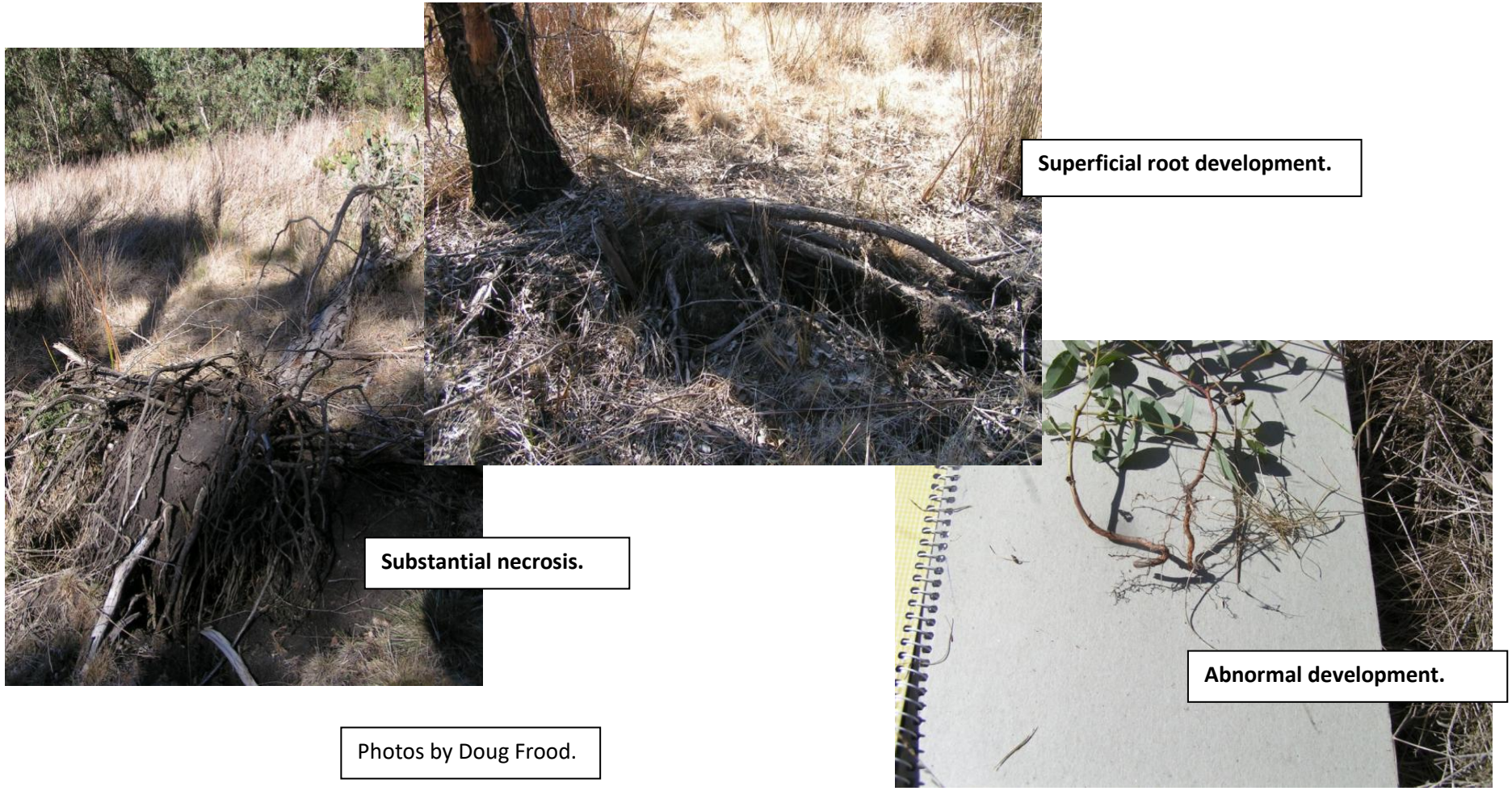


The 2015 survey showed a loss of 20 native species recorded in 1994 and 2002. Despite the very close graph lines of the 1994 and 2002, Frood in 2016, had this to say.

"***Shifts in floristic composition are apparent between each of the samplings. The 2001 sampling appears to have been under dryer conditions, as evidenced by the lack of detection of the aquatic Cycnogeton alcockiae, the apparent substantial decline of Juncus procerus, and the colonisation of the damp-site terrestrial species Sencio minimus and Holcus lanatus. However it is noted that the quadrant still supported species indicative of at some recent extent of inundation (e.g. Myriophyllum simulans) in 2001. The 2016 sampling represents a further shift towards a drier site flora, with the additional absence of the wet-site indicators Carex gaudichaudiana and Gratiola pubescens, and the active colonisation by less inundation-tolerant grass Poa tenera.The very high cover of Lachnagrostis filiformis s.l. in 2016 is indicative of unusually dry conditions at the time of sampling, particularly for a site that supported species with such high moisture requirements as the sedge Baumea articulate. A range of other indicators of modification were present in this wetland. They include deep cracking of the soils, and observed damage to root systems of Eucalyptus ovate (both young seedlings and saplings) which may be due to acid sulphate conditions. Both local***

encroachment (from the outer edges) and dieback of this species (apparently due to root damage) are evident in parts of the wetland. It is clear that this wetland has become substantially drier in overall terms, with major vegetation shifts and reduced condition apparent."

Frood also noted at this site Eucalyptus ovata saplings with substantial necrosis; abnormal development of the root systems of seedlings and superficial root development of larger trees and deflating peat soils.



Photos by Doug Frood.

Site 78/T3 Summary.

The selection of T3 as a new site is most curious. It is located within Boomerang Swamp but in the western extremity in a slightly elevated position. Site T3 has supported opportunistic woody vegetation and other native species not recorded at nearby Site 78. Site 78 was initially identified as a site of high value and dependent on a close relationship with permanent inundation. Changes since both the 1994 and 2002 surveys within this locality would have been most obvious if those people conducting the 2015 survey had previously visited this swamp. The evidence of fire is also still apparent. Of the 82 quadrants surveyed in the 1994 survey Boomerang Swamp should have been tagged as high priority during any consequence examination. The 14 year old notion that this swamp is a perched swamp and the proposition posed that excluded its "care" from anyone's responsibility should have been resolved long before 2016. It still has not been resolved. Guess work suggest it is a perched swamp but no actual evidence has been produced. Neither has the possibility of vertical downward leakage impact been investigated.

The argument has been put that being a perched swamp, the lack of rainfall and other climatic changes can be the explanation for this swamp's demise. Two things immediately come to mind if this is the case. Why survey the swamp once again in 2015 if it is believed there is no connection with the Lower Tertiary Aquifers, and secondly, if the reason for the swamp's demise is not so clear cut why hasn't downward vertical leakage from groundwater extraction been discussed or investigated?

The inclusion of this particular site adds to the confusion, bafflement and apparent haphazard manner in which the vegetation surveys have and are being conducted. But from whichever angle this site is studied, it is obvious that significant and dramatic changes have taken place since 1994.

Maggios Swamp Wetland Site on Ferny Creek.

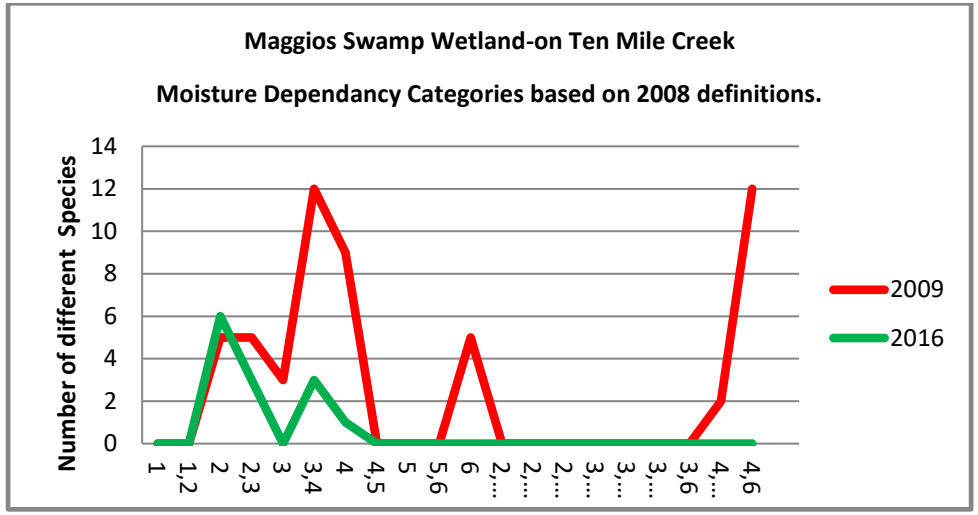
Maggios Swamp Wetland (as described in Otway Water Book 23, Chapter 16) is nestled into between logging coups that have undergone several harvesting rotations since 1973. Because this peat swamp has been so wet and impossible to drain it has undergone little to no change since European occupation. The swamp is in the head waters of Ferny Creek, a tributary of Ten Mile Creek which runs into Loves Creek, a tributary of the Gellibrand River.

For some years now Maggios Swamp Wetland on Ferny Creek has been recommended to Barwon Water and it consultant SKM/Jacobs, as an ideal site to conduct and determine a baseline for vegetation species endemic to this part of the Otway Ranges. It would have been so easy to include Maggios Swamp Wetland into the 2007 investigation of this area of the Ten Mile Creek Catchment, when SKM was conducting its investigation into extracting 16 GL/year from the Kawarren Borefield. An opportunity lost.

In 2009 Geoff Beilby was asked to visit Maggios Swamp Wetland and make a list of vegetation in the swamp and adjoining verges. In 2016 Doug Frood was also asked to visit this swamp and carry out a cursory survey. At this 2016 visit and to my eye, Maggios Swamp Wetland had not altered since first visiting the swamp in the 1990s. This peat wetland maintained its integrity throughout the drought period from 1997 to 2010 and is testament to the way other

similar wetlands in this part of the Otway Ranges should have prevailed. An extremely and easily accessible site for the collection of baseline and follow up data.

Site								2009 Beilby				2016 Frood	
								Native	Exotic			Native	Exotic
Maggios	Total species each survey							54	0			14	0
	Same species as previous surveys											12	0
	New species from previous surveys											2	0
	Species not recorded from previous surveys											40	0



Beilby found Maggios Swamp Wetland to be a combination of several small peaty permanent swamps with vegetation across the site that varied because of the different aspect, slope, soil, and moisture conditions. ***The areas of most interest are the peaty swamps, which have a canopy of tall Swamp Paperbark (Melaleuca squarosa) and Manuka (Leptospermum scoparium), an understorey of Victorian Christmas Bush (Prostanthera lasianthos) and a ground cover of Sword Sedge (Lepidosperma laterale) and a range of ferns. Of the ferns, the most interesting were large King Ferns (Todea Barbara) some exceeding one metre in stem diameter and height, and fronds over two metres long.***"

Beilby had this to say about these King Ferns, "***... specimens on this site are the largest and healthiest I have seen and of considerable age.***" Testament to the undisturbed state of Maggios Swamp Wetland over eons.

Frood found the slopes leading into Maggios Swamp Wetland wet underfoot and the gully supporting tall Melaleuca squarosa with ferns, and additional species present on the lower slope including Tetrarrhena juncea, Ghania sieberiana and Eucalyptus viminalis. The King Ferns observed by Beilby were still in excellent condition.

Maggios Swamp Wetland is perhaps the closest, one could go to achieving a true control site against which comparison of impacted sites within the drawdown influence could be rated. This site presents itself as similar to what the Big Swamp (T1) was like pre groundwater extraction.

Comprehensive Monitoring Program Assertion.

Barwon Water continues to be of the view that the monitoring program they instigated in 2014 is comprehensive and one of the factors ensuring the licence to extract is operated sustainably. "***Latest figures from Barwon Water's comprehensive monitoring program show groundwater levels in the area have recovered significantly since the borefield was last operated. The Barwon Downs borefield is operated under a licence issued by Southern Rural Water, which ensures the groundwater source is operated sustainably.*****" (Colac Herald, letters to the Editor, Friday 18 March 2016.)** The groundwater levels have not recovered significantly. Barwon Water's 2014-2015 financial year groundwater report had the Pebble Point aquifer drawdown recovered from -60 m to -27 m since pumping ceased in 2010. In volume this is approximately a 13% recovery. The 2015-2016 report had it drop back down to -50 m due to a 1903 ML extraction between April & July in 2016.

Back in 2008 Barwon Water Managing Director, Michael Malouf, had this to say in a Media Release, Barwon Water, December 16, 2008, Ref: 233/08, that "***Currently there are more than 60 observation bores monitoring water levels and salinity and there had been a significant number of related investigations. The vegetation monitoring component is an element of that continuous process. It was established in 1994 to improve our understanding of the interaction between groundwater, surface water and the health of native vegetation in recharge areas.***" Unfortunately 14 years later, it was concluded by Barwon Water in the 2008 vegetation study that the accumulative effect of all studies since 1994 have been inconclusive.

The following table (pages102-103) summarises the vegetation study recommendations made over a thirty year period that forms part of this "*comprehensive monitoring program*" carried out by Barwon Water. Copies of these recommendations can be seen in Appendix 1, 2, 3, 4 and 5, pages **113** to **121**. This table throws considerable doubt on the veracity of the above assertions.

In 1986 Quentin Farmar-Bowers of the Rural Water Commission (now called Southern Rural Water), when preparing a report on vegetation studies to be conducted in the drawdown area of the Barwon Downs Borefield, he had these things to say.

1. It was possible, and essential, that the structure and species composition of vegetation that had developed with an interaction with groundwater tables should be established.
2. Mapping these sites would define the extent of possible impact caused by falling groundwater levels.
3. Groundwater levels had been relatively stable for years.
4. Falling groundwater levels will probably have an acute impact on vegetation at springs and swamps declining into chronic and marginal to trivial impact.
5. Permanent sites should be established coupled with,
6. long term monitoring that would enable an accurate description of these impacts.
7. This data would provide a baseline for comparison.

Nothing done until 1991 when a study brief was tenured & and service contract let.

No vegetation monitoring investigation was followed up until 1991 when Barwon Water began preparations applying for a groundwater extraction licence.

Year report finished.	Recommendations made.	No. of sites indentified	Stated as new sites.	Previously Recommened	Year Implemented	Comments.
1992 Ecology Australia	• Develop a carefully designed monitoring program. • Mark permanent sites • Design a long term monitoring program • Have control sites • Investigate & implement amelioration	82	82	Yes Yes Yes Yes	- - - -	Hydrologically sensitive vegetation sites identified for the first time. The collection of this data and establishment of reference points begun. Aim of this work was to justify the application for an extraction licence, Stage One.
2002 Ecology Australia	• Design & implement a monitoring program • Mark permanent sites • Design a long term program • Have control sites • Determine frequency of monitoring • Monitor watertable at the sites	24	0	Yes Yes Yes Yes	- - - 2004	None of the 1994 recommendations implemented. When approaching the renewal of the Stage One licence Ecology Australia was asked to prepare a brief report on previous sites with a further emphasis on hydrological sensitive vegetation sites. The licence renewal process made a half hearted effort to set up some control sites.
2008 Ecology Australia and SKM	• Design & implement monitoring sites • Design a long term monitoring program • Mark permanent sites • Monitor water table at sites • Investigate the impact from pumping on these sites	8	5	Yes Yes Yes Yes Yes	- - - 2015-2016	None of the previous recommendations were implemented. In May 2009 Barwon Water was asked by way of Freedom of Information to provide copies of the long term vegetation hydrological monitoring program, the permanently replicated

	• Determine frequency of monitoring			Yes	-	plots, the control sites etc. [46] as outlined in the Ecology Australia 2002 report. The reply being "*We have not located any documents relating specifically to the above request*."[46] The 2008 report was summarised by Barwon Water as having inconclusive results regarding any causal impact due to groundwater extraction at the Barwon Downs Borefield. (Colac Herald 27 April 2009)
2015 Jacobs	• A new start was made and that this report outlines baseline conditions for future monitoring as recommended in previous flora surveys • Envisaged that future monitoring rounds will be able to use the data captured in this report as a baseline against which changes can be measured • Key questions to be analysed have been identified for each new site • Surface level at each site yet to be determined • There will be subsequent reports following • An observation bore within 500 m for each of the 14 sites established	14	14			New monitoring bores have been have been drilled in association to these 14 sites if there wasn't one already located at the site. Not all of the new bores are in close proximity to the vegetation site. The term Control Sites is no longer used in the 2015 report. Reference Sites appear to be its replacement but are stated as outside any impact from pumping. No visible permanent marking of the new sites apparent. Grid references for these sites are confusing and in some instances inaccurate (see pages **112-113**).
2016	A follow up vegetation study to the 2015 survey concludes that the Barwon Downs Borefield ***has had no impact*** on hydrologically sensitive vegetation in the drawdown are of influence.					

Jacobs' Barwon Downs Vegetation Monitoring Report to Barwon Water, 7 July 2015.[120]

Before concluding Otway Water Book 31, some comment needs to be made specifically targeting the SKM/Jacobs 7 July 2015 Barwon Downs Vegetation Monitoring Report prepared for Barwon Water.[96][120] This report was commissioned as part of satisfying the groundwater extraction licence conditions (see Appendix 14, page 170 for the 2004 vegetation survey conditions, & Appendix 15, page 177 for the 2014 revised licence conditions).

Throughout the sections titled Executive Summary, Introduction, Methods, Statistical Analysis, Results, Summary Statistics, Discussion and Conclusion of this 2015 report, there are numerous statements made that must be challenged.

1. **Land Use Change.**

Not being able to calculate "***land use change***" influence was one reason given why previous flora surveys were inconclusive. At no stage has Barwon Water attempted to determine land use change over any period since European settlement, let alone during the groundwater extraction periods. If this is never done then this perceived influence will always be given as a reason for an inability to calculate accurately the impact from groundwater extraction at the Barwon Downs Borefield. However, Otway Water Book 28 discusses such an attempt at determining the influence of land use change and has concluded that any influence will have been minimal since 1977. Extensive groundwater extraction commenced in the drought of 1982-83.

2. **Vegetation Sites.**

2.1 Jacobs states that 3 of the 14 sites surveyed in 2014 were in the vicinity of previously assessed flora sites. However, after some examination...

Site T2	Is in the close proximity to ...	Site 25	Surveyed in 1994 & 2002
Site T3	Is within metres of...	Site 78	Surveyed in 1994 & 2002
Site T7	Is in very close proximity to ...	Site 3	Surveyed in 2008
Site T8	Is in very close proximity to ...	Site 40	Surveyed in 1994
Site 11	Is in very close proximity to ...	Site 2&3	Surveyed in 1994
Site 12	Is in very close proximity to ...	Site 15	Surveyed in 1994 & 2002

2.2 Sites designated as sites possibly impacted from the Barwon Downs Borefield extractions, were located in two areas.

2.2.1 One area of selection was from the unconfined part of the aquifer where the watertable was known to have been affected from past pumping. "...***impact sites were located in areas of the aquifer where the watertable was either known to have been affected from past pumping (in the unconfined areas)***..." At no point in this report has this statement been qualified or quantified naming the sites or areas affected. Neither has the impact been enunciated. These undefined sites should have been the ones resurveyed, not establish 14 "new" ones in

2014-15. Jacobs state these very close but "new" sites cannot be compared because..."***Given the monitoring regime has significantly changed from previous surveys, and the majority of sites have been established at locations not previously assessed, either for flora or groundwater levels, no comparison with past surveys is possible for this assessment.***" This seems to be a tenuous argument. The area studied has numerous observation bores, one of the most intensely monitored in Victoria for water levels in the Lower Tertiary Aquifers.

2.2.2 The other locations chosen for impact sites were in the confined aquifer area with potential to suffer impact. Any impact in these cases would have to include downward vertical leakage but no such explanation has been given.

2.2.3 The final type of vegetation sites were chosen as " reference" sites, where it was determined by Jacobs that these sites were outside the drawdown influence caused by the Barwon Downs Borefield. "***Reference Sites were located where no impact on water levels in the aquifer caused by the Barwon Downs borefield was observed (or is expected to be observed under future pumping scenarios).***" Actually all sites chosen were inside the drawdown influence and as a result vertical leakage and other observable impacts could occur long after the cessation of pumping. So, in that regard there may well be no observable impacts during pumping episodes, but it does remain that all of the sites are within the area of drawdown influence.

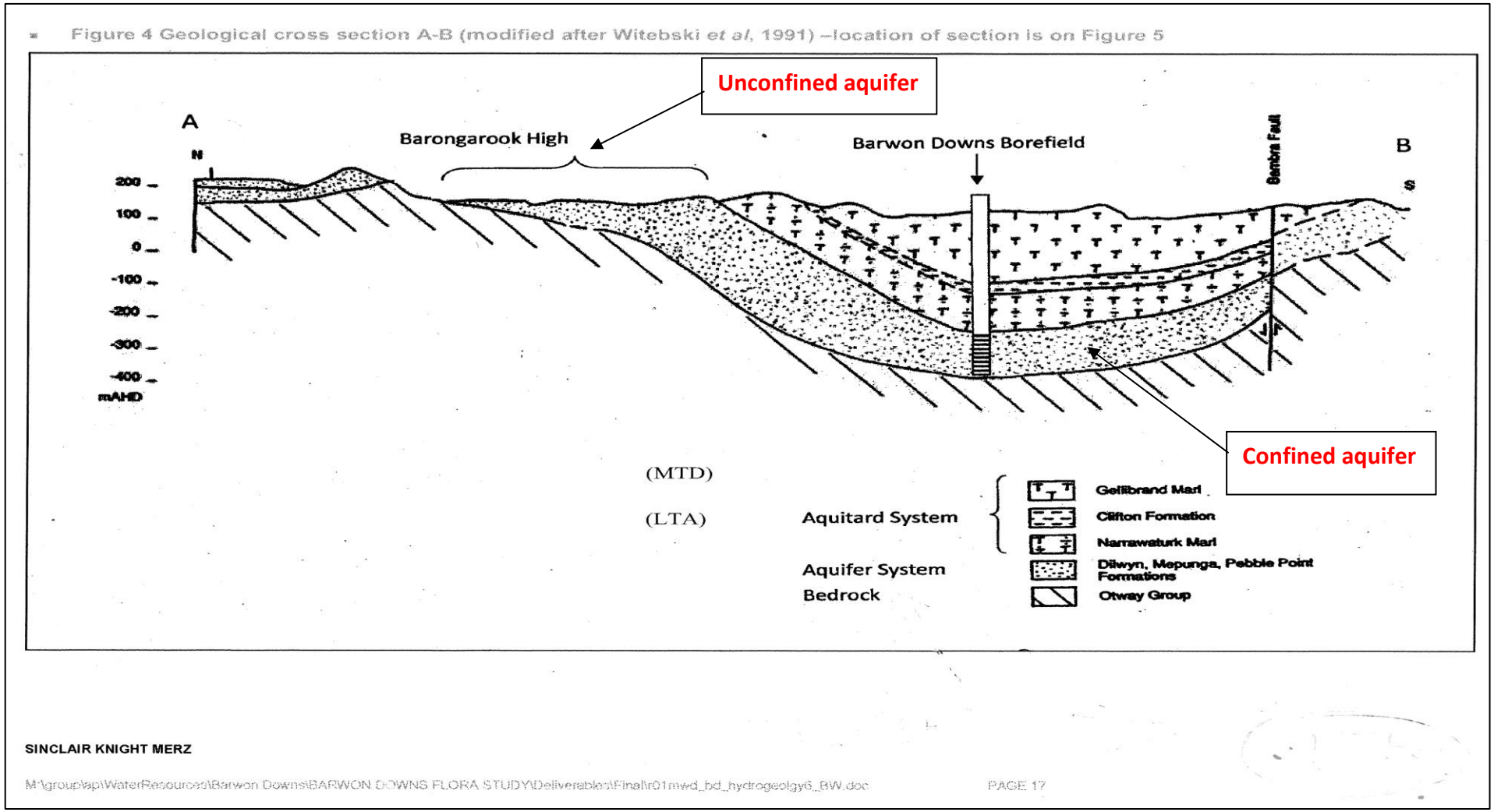
(It would appear that Jacobs has opted to call ***the control sites*** as stated in the 2014 revised licence conditions, ***reference sites***. This adds somewhat to the confusion as to the intention of these sites – see Appendix 15)

The 2015 report indicates the following ...

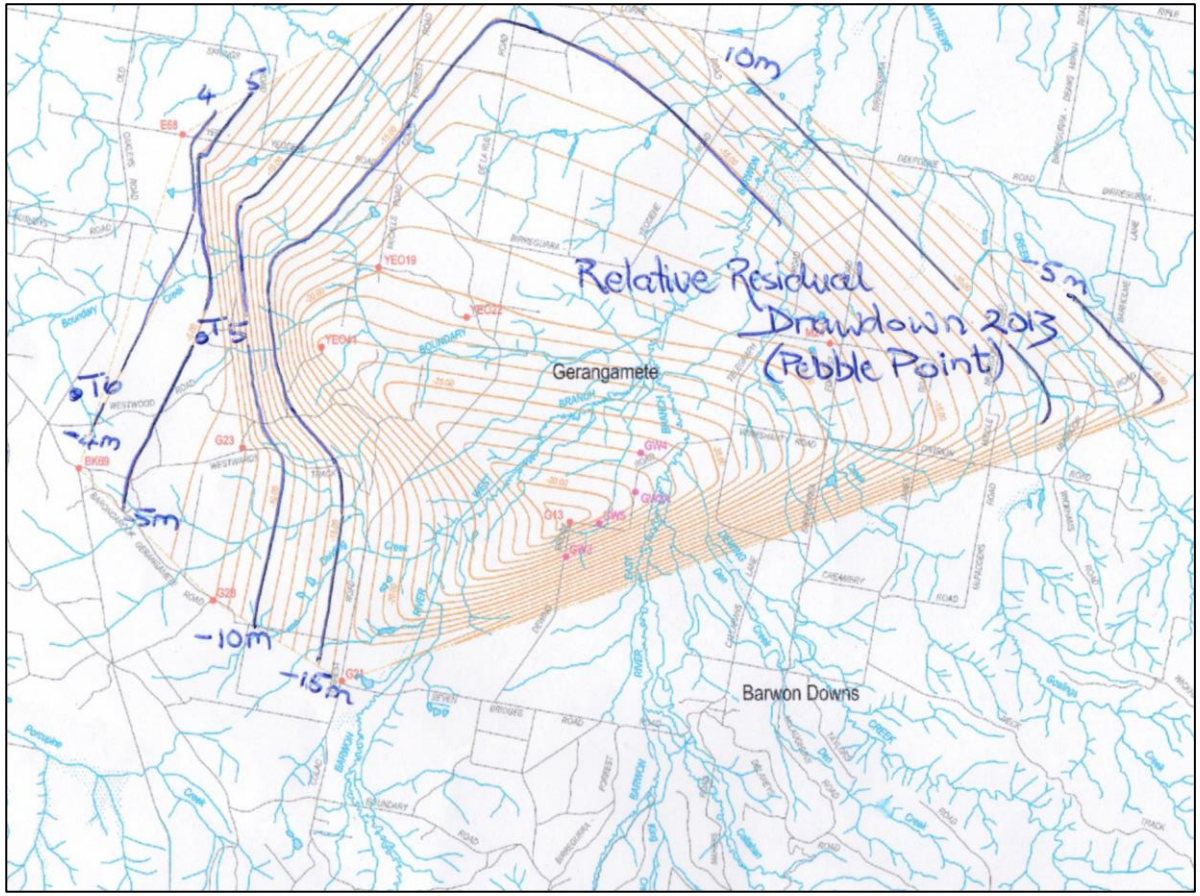
Reference Site Number	**Relation to Aquifer**	**2016 Drawdown since new observation bores were sunk in 2014-15.** **(This period covered six months of observation)**
TB5	unconfined	Water table has maintained a relatively stable level
TB6	unconfined	Water table has maintained a relatively stable level.
TB7	confined	A drop of approximately 1 metre.
TB11	confined	A drop of approximately 0.75 metres.
TB12	confined	A drop of approximately 2.25 metres.
TB13	confined	Drop of approximately 1.5 metres.
TB14	confined	A drop of approximately 1.75 metres.

(The "B" notation signifies the bore associated with a vegetation site. e.g. TB5 is the observation bore site for vegetation site T5)

These watertable drops in 6 months are quite dramatic when considering GHD concluded from a Regional Groundwater Monitoring Network Review for the Deep Water Aquifer System (Lower Tertiary Aquifers) in South West Victoria (2006),[17] that levels in the Western District could be expected to fall at 10 cm a year. That is 1 metre in ten years. It is arguable that the reason for the relatively level watertables at Sites T5



and T6 where no downward trend is happening, is because of the masking and buffering effect felt by the Artificial Supplementary Flows being released upstream of these sites.



This map prepared 3 years after the borefield was last in operation, shows the residual drawdown from groundwater extraction. These contours were prepared using observation bore data from the area. As can be seen there is a considerable drawdown in the vicinity of the T5 and T6 vegetation sites. However, the watertable levels at these two sites, shown in the Jacobs 2015 vegetation study, indicate no fall in water levels. As discussed this is most probably a result of a masking effect created by the artificial supplementary flows being released out of the Otway to Colac Pipeline. These 2 ML/day of artificial flows disappear into the unconfined area of the depleted aquifer starting in the T5 and T6 area.

The historical observation bore data strongly indicates that all of the 2015 reference sites come within the drawdown area of impact from the Barwon Downs Borefield (see pages 18, 26 & 107).

2.3 "***No difference between the impacted and reference sites was detected at this time.***" (2015). The fact that this assertion was based on a very limited time frame and the previous 30 years of impact at these sites is completely disregarded, can be lost to the casual reader. Selecting new sites in 2014 combined with a disregard given to earlier observation and survey data ensures that this statement when taken at face value will not be challenged. This is a clear case of plausible misdirection.

2.4 The fact that close examination of historical observation and readily available data would "paint a different picture" is lost to the casual reader of the 2015 report. Pre-pumping, T1/Big Swamp, was a saturated site located in a water covered swamp within a dense Melaleuca squarosa wetland. Jacobs states that this swamp is now in recovery mode but also states it has no data on what the swamp was originally like. Until after the start of groundwater extraction and the swamp dried out, there no were no eucalyptus trees within the top end of the swamp. Now the swamp is covered in species of plants originally only found at the verges of the swamp (see right hand photo page **109**). In the initial stages of this so called recovery the swamp has been invaded by drier opportunistic vegetation that did not form part of the swamp habitat pre groundwater extraction. The water table is still metres below the swamp surface (see page **51**) despite the 2 ML/day releases from the Colac system. These opportunistic eucalyptus trees will survive until the watertable returns to normal or the toxins being produced in the acid sulfate soils reach the root layer (see pages **110-111**).

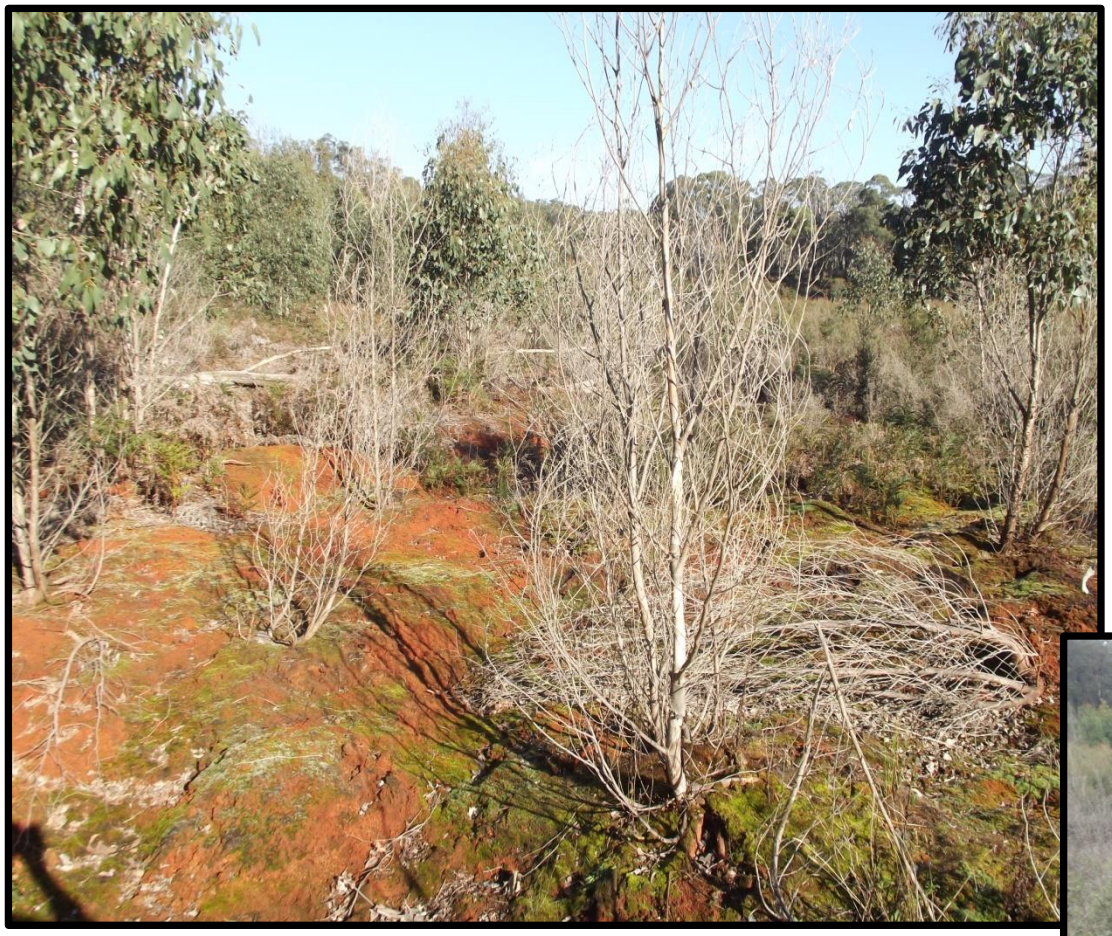
A reference site most applicable for comparison with impacts that have taken place in the Big Swamp, would be Maggios Swamp Wetland. Maggios Swamp Wetland is similar to the way the Big Swamp Wetland was pre groundwater extraction and is by far the best example of this type of hydrologically sensitive vegetation still existing in the 2015 study area. Maggios Swamp Wetland is in the head water of Ten Mile Creek. Recommendations that this is by far one of the best sites as a "reference/control" site have been ignored.

Site T14 on a tributary of Ten Mile Creek, is the next best site for comparison with the way the Big Swamp and other wetlands would have looked pre groundwater extraction, and as a result would be a very good site for future comparison – close to being a control site. However, Jacobs for some unknown reason states Site T14 will only be referred to in future surveys if one of the other reference sites is unavailable. Site T14 is to be kept in reserve. "***...and Site 14 is a "spare site" to be included should any one site not be available.***" Site T14 is arguably the best so called control site of the 14 "new" sites and no where in the 2014 modified licence conditions is there a reference to T14 being kept in reserve. This idea of T14 being kept in reserve is a home grown decision and if implemented, would require ratification and another change to the licence conditions.

The next best site is Site 3 on another tributary of Ten Mile Creek that was first surveyed in 2008. However, this site was moved in 2015 and renamed Site T7. Another example of comparative data being curtailed.

Stating that there is little difference between impact and reference sites tells only a fraction of the story based on a truncated timeframe and limited data.

This is approximately the same site in the Big Swamp. Before the fire in 2010 the Melaleuca squarosa swamp had dried out and the site turned toxic with the swamp dying. After the 2010 fires, opportunistic eucalypts and other species have colonised the swamp. However, as can be seen on the next page, after a wet winter or two the acid created, rises with the watertable and kills off the vegetation. This has happened in the past and it is anticipated that as the swamp attempts to return to pre pumping saturated conditions there will once again be dramatic changes to the vegetation composition of the Big Swamp.



These pictures show opportunistic vegetation that showed signs of “recovery” soon after the millennium drought broke, but then died off as the acidic and toxic watertable interacted with the roots structures in the wet winters of 2013-14. The photograph on the next page shows an attempt by one of these opportunistic plants struggling to survive by spreading roots above the toxic level.

3. **Community Concern.**
On numerous occasions Maggios Swamp Wetland has been suggested as a site that should be included in any survey work. The first time this was raised with Barwon Water was in 2007 when investigations into the feasibility of extracting water from Kawarren was proposed. As has been the case for decades little notice has been taken of local community concerns and or suggestions.[36]

4. **The 2015 Jacobs Report made some *EXTREMELY* inaccurate comments about Previous Vegetation Studies and Reports.**

4.1 *Comment* by Jacobs on *the 1994 Study conducted by Ecology Australia*.
Jacobs states that the 1994 survey was "***general in nature***". This could not be further from the truth. The brief given to Ecology Australia in 1991 was specific, targeted and unambiguous (see pages **12-13**). The extensive report fulfilled the demands of the brief with a detailed, extensive and comprehensive report. Baseline data of Groundwater Dependent Environment sites were expertly established and recommendations made that were seen to be essential for follow up work.
(Unfortunately, the Jacobs 2015 report made no mention of this or that there had been no follow up on the 1994 report until the Stage One licence renewal was coming up for review in 2002. Even then efforts were concentrated on licence renewal rather than comprehensive investigation building on the data already collected.)

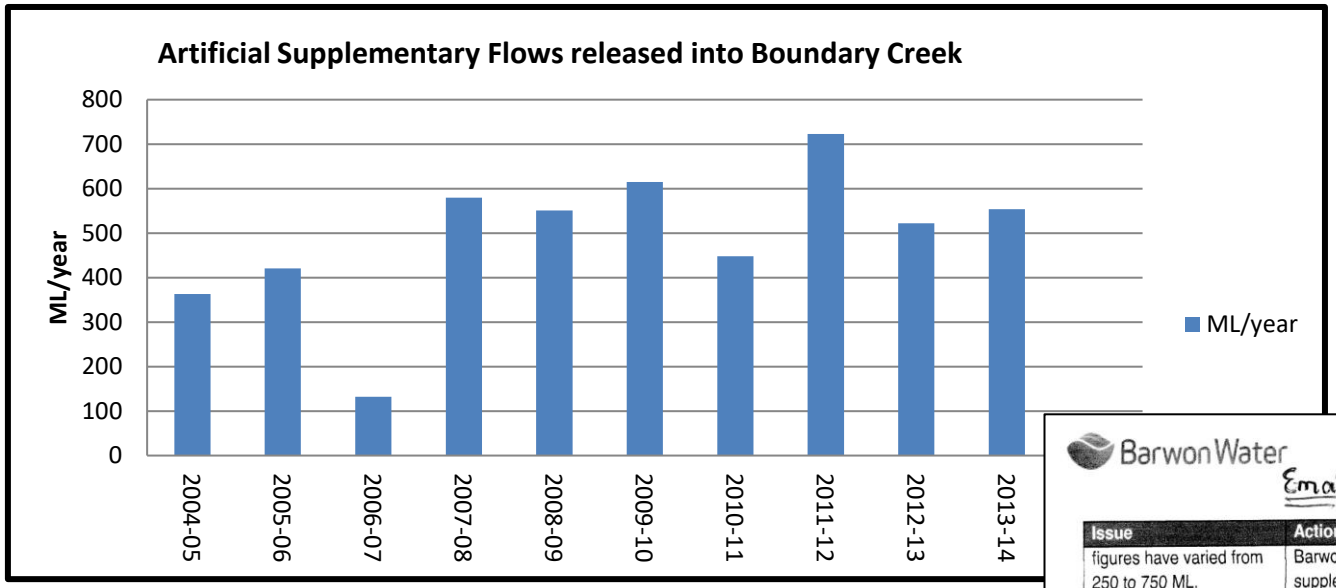
4.2 *Comment made by Jacobs regarding the 2002 Study conducted by Ecology Australia.*
The Jacobs summary states that the 2002 report "***...found that vegetation comparison had changes due to decreased moisture availability but could not indicate whether this was due to drought, groundwater extraction, or supplementary watering (Boundary Creek environmental flow releases as stipulated in Clause 6.1 of the licence) or a combination of all three, Carr 2002)***" This is an amazing statement in several ways.

Firstly, Clause 6.1 in the licence conditions does not stipulate what the artificial supplementary flow releases are actually for. It is problematic whether they are for the environment, stock and domestic requirements, or both. However, they most definitely are not solely for the benefit of the environment.

But whatever the reason for these releases it is inconsequential as the "***environment flow releases as stipulate in Clause 6.1 of the licence"*** did not commence until at least 2 years after the completion of Carr's 2002 report. Clause 6.1 was a condition of the 2004 groundwater extraction licence and not one drop of supplementary water had been released because of Clause 6.1 until after the 2002 report was finalised. Carr most definitely made no such statement.
To add more confusion, recent correspondence from Barwon Water leads one to believe the releases actually started in July 2006. From other data sources this 2006 start seems most unlikely. In the 2004-05 financial year report on groundwater

extraction sent to Southern Rural Water, the artificial supplementary flows commenced in 2004 or there about (see Appendix **14** and page **170**). Strangely the impact from this supplementary watering gains scant reference in the 2014-2016 reports. Thirdly, what the Jacobs quote does highlight is the readiness to discount the importance of earlier studies. And fourthly, these quotes highlight a failure by Barwon Water to be proactive. Implementing any of the 1994 recommendations has taken decades and making a concerted effort to unjumbled the cause of the 2002 and 2008 vegetation impacts has never really been attempted. Successful licence renewal has always been the major motivation for works done.

to



SOURCE: Barwon Water yearly reports Southern Rural Water.

What these comments above highlights is how easy it is for new personnel to discount and or not be aware of earlier data. Unfortunately, it would appear that all persons dealing with this new monitoring program are "Johnny-come-latelys" lacking any long term familiarity with the area, issues, past studies and or connectedness with the local community.

Barwon Water

Email: 15 April 2016 10:40 to otwaywater@yahoo.com.au

Issue	Action	Timeframe
figures have varied from 250 to 750 ML.	Barwon Water releases supplementary flow to Boundary Creek under clause 6.1 B of the Gerangamete groundwater licence. To date, 4,644 ML has been released over 01 July 2006 to 30 June 2015 to Boundary Creek, making it 520 ML on average per financial year. The variability is due to the nature of the licence conditions which trigger the requirement for supplementary release.	

4.3 *Jacobs 2015 summary of the 2008-09 Report.*
Jacobs states that this study was unable to untangle the impact groundwater extraction was having from the "***many factors***" influencing the drying out of the vegetation. However, Otway Water Book 9[46] presents a totally different conclusion. Using readily available data Book 9 demonstrates that groundwater extraction from the Barwon Downs Borefield is the major contributing factor responsible for moisture depletion in the hydrologically sensitive vegetation sites surveyed in 1994.

The Jacobs's summary also includes this statement that there is a "***...possibility of highly localised perched water tables, and masking influence of outflow from adjoining stream and river systems.***" I cannot recall reading any mention of or reference to masking streams and river systems in the 2008-09 report. These masking stream and river systems are a figment of someone's imagination and highlights once again the lack of familiarity with the area and earlier reports. However, the 2008-09 report most definitely did comment on the possibility of perched water tables. This reference stated that ***there was no evidence or data to support the notion of perched watertables.*** In the development of the 2004 licence conditions the Boomerang Swamp, a site of State significance, was to be protected with specific licence conditions. However, SKM determined that this swamp was not connected to the influence of the Barwon Downs Borefield pumping and that the swamp was sitting on a perched aquifer. As a consequence the 2004 licence conditions protecting this swamp were deleted from the licence. Then, in 2008 SKM stated there is no evidence to support perched aquifers in the area. Now, once again in 2015 Jacobs states, without offering documentation, that T3 sits on a perched aquifer (see point 6 below). Whatever the truth, Boomerang Swamp has suffered severe impact from some form of influence.[67]

The Jacobs 2015 report failed to mention the series of recommendations the 2008-09 report made, and that these recommendations mirrored the ones made years before. If a genuine effort to understand and care for the water sensitive vegetation sites was held, then these recommendations would have been implemented back in 1986. Unfortunately, each vegetation study that has been undertaken since 1986 has been prompted as a lead up and used as supporting argument for the justification of groundwater extraction licences. At each stage any concern for the environment and local issues sadly faded into the background.

5. Hydrogeological data.
The 2015 Jacobs report appears to make contradictory comments regarding the adequacy of available hydrogeological data. The area being studied is one of the most intensely observation bore areas in Victoria and as a consequence there is extensive observation bore data to draw upon.
This Jacobs' statement supports this fact. "***Consideration of more up to date hydrogeological data enabled a more accurate delineation of impact and reference sites.***"

At the time of the "***more accurate delineation***", no new observation bores had been drilled. The more accurate delineation would have been made using pre 2012 observation bore data. This very same data should have been, and could have been used in conjunction with previously surveyed vegetation sites achieving a successful, and would have produced an "untangled" outcome, regarding impact on hydrological sensitive vegetation sites. A direct connection between groundwater extraction and de-moisturising of hydrologically sensitive vegetation sites would have been better understood. As this data is still available this "untangling" is still possible.

To justify the movement of some vegetation sites stating that they would be closer to new observation bores drilled specifically to help understand the hydrological connection is difficult to believe and appears quite dubious. The TB1 observation bore site was newly drilled 550 metres from the vegetation site. The T1 site was at the top end of the Big Swamp and TB1 was drilled at the bottom end of the swamp. And, another contradiction is apparent with the newly drilled TB3 bore being located over 200 metres from the T3 location.

Justifying removing and or moving previous vegetation sites because they ranged between 50 to 300 metres away from an observation bore, would be a very hard argument to substantiate as a reason for making a "new" start in 2015.

6. Perched Aquifers.

On page 8 of the Jacobs 2015 report 2008 Site T3 has been excluded. "...***as Site T3 was found to be unconnected to groundwater sources used by the Barwon Downs borefield(i.e. is a perched swamp).***" So once again a definitive statement claims Boomerang Swamp (T3) to be a perched swamp. This statement has to be qualified and proof provided clearly showing Boomerang Swamp to be sitting on a perched swamp, and, that it is NOT being impacted by downward vertical leakage from groundwater extraction at the Barwon Downs Borefield.

In 2002 SKM/Jacobs stated that Site 78 on Boomerang Swamp was on a perched aquifer and as a result was able to substantially alter the manner in which this swamp was managed. Then, in 2008 SKM stated there was no evidence to substantiate the notion that there were any perched aquifers in the area. Now once again in 2015, SKM/Jacobs states, without justification that T3, located in the same swamp and within metres of Site 78, sits on a perched aquifer. Because of the "mixed" history involving Boomerang Swamp, it is most baffling why T3 was ever selected as one of the 14 "new" vegetation monitoring sites only to be dismissed once again.

7. Spare Site.

T14 has also been excluded from further study as it is needed "***...should any one site not be available.***" Why any site would not be available is difficult to imagine. Also, the licence conditions make no mention that control Site T14 is to be kept in reserve.

Site T14 is on a tributary of the Ten Mile Creek and was to be a reference site or control sit. This site on a tributary that was non flowing at the time of the survey, goes close to being a comparative site to many of the 1994 sites and should be maintained as a reference/control site. However, why a site was not chosen along the main branch of the Ten Mile Creek where there is permanently flowing water and ideal swamp type riparian landscape similar to the way the Big Swamp was pre pumping, has not been explained satisfactorily.
"***Ten Mile Creek was proposed as a site for vegetation assessment but was altered due to significant likelihood that Cashins Road and the Old Beechy Train which run along the edge of the Creek would have a compounding influence on the vegetation assemblage at this location.***" Perhaps this statement is meant to say "Trail" not "Train" as the last train ran back in 1962.

If this compounding influence from the Beechy Rail Trail is such a factor then T7, another reference site upstream on another tributary of the Ten Mile Creek should also be kept in reserve. "***The start of the transect*** (T7) ***is located – 25m north west of the monitoring bore TB7 and is close to the Old Beechy Trail which is located approximately 50 m to the north.***" Surely this site also had a *compounding influence*, what ever that merans.

Maggios Swamp Wetland at the headwaters of the Ten Mile Creek where the aquifer permanently overflows, would have been by far the best and most appropriate control site.

8. Site Co-ordinates (Grid References).

Sites T12 and T13 on pages 31 and 33 of the 2015 Jacobs report have the very same grid reference co-ordinates. However, these sites are at least one kilometre apart (see page **27** of this book).
Sites T8, T9 and T10 on pages 23, 25 and 27 of report 2015 have the same grid references. These sites are approximately 3 kilometres away from one another.
Sites T2, T3 and T4 on pages 11, 13 and 15 of the 2015 report have been given the same grid references. The sites vary in position ranging from one to two kilometres apart.
In the Appendix C data sheets Jacobs have Site T1 east of the Colac Forrest Road when the site is west of this road;
Sites T6 and T7 are described as being "***Located at unnamed tributary of Boundary Creek on an unnamed access track off Landons Road – 400 m from turnoff.***" The named access track is probably meant to be Langdons. Also, T7 is about 2 km away from this site on a tributary of Ten Mile Creek not Boundary Creek, and
Sites T9 and T10 are both reported to be "***Located on Porcupine Creek on Pipeline Road – 2 km north of the intersection with Colac-Olangolah Pipeline Track.***" Site T10 is shown on the Jacobs map to be on a tributary of Dividing Creek about 5 km away.

One reason given for making a "new" start in 2014 has been that previous vegetation sites have been difficult to revisit because of the inaccuracies of site locations in preceding studies. It is quite possible that another "new" start will be required in the next bout of vegetation studies due to the inaccuracies of the 2015 work.

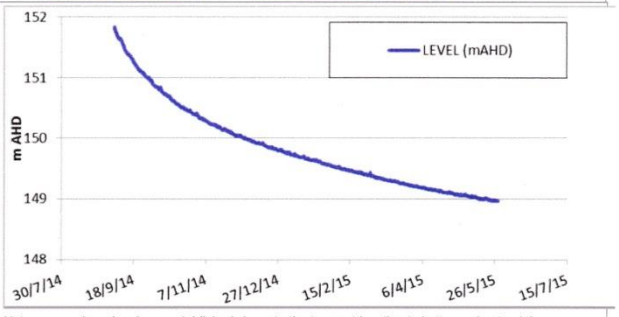
Note: No effort has been made to check all material presented in the 2015 Jacobs report. These discrepancies were noted when researching other aspects of the report.
Also Note: The Grid references given to the 14 "new" vegetation sites in the amended 2014 groundwater extraction licence (see Appendix 15) add more confusion regarding the exact location of sites. The 14 "new" sites are located in Zone 54 but are referenced or benchmarked from a location somewhere in Zone 55. Also, the grid reference headings of ***East (255)*** and ***North (255)*** took some time to make sense of. Both bracketed numbers should read (Z55), meaning Zone 55, then some sense of the baffling Eastings and Northings can be made.
When notified that the co-ordinates are confusing the reply came back from Jacobs stating that once it is known that Zone 55 should be Z54 the co-ordinates read correctly. Another effort has been made to point out that the Zone reference is only a minor problem with the vegetation site co-ordinates given in the 2015 report. At the time of completing this book there has been no clarification given.

9. Comparing the Jacobs Summary Sheets for Sites T2 and T3.

When comparing the Jacobs Summary Sheets for Sites T2 and T3 some alarming discrepancies can be noted.

9.1 As previously pointed out the transect co-ordinate grid references are identical for the two sites that are at least 2 km apart.
9.2 There are no "...***un-named private road***" anywhere near Site T3 that is located in the Otway Forest Park.
9.3 Observation bore TB3 is approximately 200 m from T3, not 20m.
9.4 The access track at Bore T3 is to the west of the bore not the east.
9.5 Site T3 is a considerable distance from Boundary Creek and there are no multiple meandering channels as stated.

Site T2 (existing)	Boundary Creek	IMPACT, UNCONFINED

Location Description	Located at Boundary Creek. west of the crossing of an un-named private road. Access was achieved from the south side of the creek along an unmarked but well made access track to the east of the bore location located ~ 100 m south of the transect. The transect covers 40 m from the edge of the track due north and crosses Boundary Creek which has multiple meandering channels at the site. The transect is marked with a yellow-capped post within 3 m of the edge of the access track.
Location Co-ordinates	**START:** E734632, N5744000; **END:** E734654, N5744034
Depth of Groundwater at TB2	 Note – a new bore has been established closer to the transect location to better understand the groundwater dynamics at this site but data is not available for this report.

Vegetation Description — **Diversity:** 27 species (26 native, 1 introduced)

The transect traverses Boundary Creek which has multiple channels at this location. The first and last quadrat are located outside the wider channel at the margins whilst quadrats 2, 3,4 have water present and incorporate at least some aquatic species and quadrat 6 encompasses the main channel at this location.

The overstorey comprises Swamp Gum (*Eucalyptus ovata*) although most trees are rooted at the margins of the creek and overhanging the quadrats. A dense shrub layer dominated by Scented Paperbark (*Melaleuca* squarrosa) is present throughout over a variable groundlayer. At the margins of the swamp, the ferns Pouched Coral-fern (*Gleichenia dicarpa*) or Mother Shield-fern (*Polystichum proliferum*) dominate whilst sedges such as Tall Sedge (*Carex appressa*), Red-fruit Saw-sedge (*Gahnia sieberiana*) and Tall Sword-sedge (*Lepidosperma elatius*) are dominant. Obligate wetland species requiring at least semi-permanent surface water that are present include Club-sedges (*Isolepis cernua* and *I. innundata*), Water Ribbons (*Cycnogeton procerum*) and Austral Brooklime (*Gratiola peruviana*).

Holes for burrowing crayfish, likely the Otway Burrowing Cray were evident throughout the alignment particularly in quadrats 4-6.

Vegetation Condition: In good condition – no evidence of dieback and recruitment evident

Evidence of Change: None observed

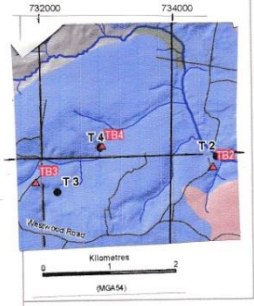
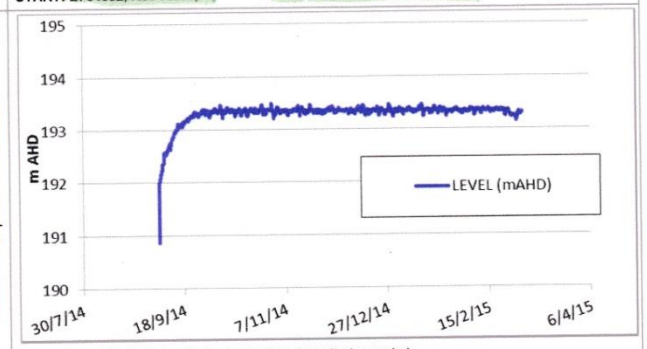
Notes for future monitoring rounds: As managed flows are released into Boundary Creek, any monitoring of this site should consider any changes in flow regime and monitor changes in category 5 plants on the margins of the waterway and pools. Significant recruitment was also noted in quadrats 3-7 and could result in significant changes in those quadrats should conditions remain static (i.e. limited to no groundwater use, consistent water flows and rainfall etc.).

Comparison to 2008

The transect described is in the vicinity of Site 1 described in the 2008 study though not directly comparable. The 2008 study noted a general recovery of water dependent ferns and sedges from 2002 (potentially due to provision of environmental flows down Boundary Creek) and the presence of these is confirmed by this assessment where these species are in good health. The windthrow noted in 2008, attributed to a drying of the upper soil strata, was not noted at the transect assessed.

JACOBS

Site T3 (new)	Perched Swamp	IMPACT, UNCONFINED

Location Description	Located at an unnamed swamp with standing water across a 1.2 ha area east of an un-named maintenance track running north off Westwood Track and west of crossing of an un-named private road. Access was achieved from the south side of the creek along unmarked but well-made access track to the east of the bore location located 20 m uphill from the transect. The transect covers 40 m from the edge of the track and crosses Boundary Creek which has multiple meandering channels at the site. The transect was located at the western end of the swamp as it appeared to drain to the north east and any potential changes are more likely to be detectable at the upper end and at the edge of the swamp.
Location Co-ordinates	**START:** E734632, N5744000; **END:** E734654, N5744034
Depth of Groundwater at TB3	  Note – bore still stabilising during beginning of monitoring period.

Vegetation Description — **Diversity:** 11 species (11 native)

A sedge and rush dominated wetland in standing water (to 35cm at transect but likely deeper toward centre of swamp) with Swamp Gum (*Eucalyptus ovata)* trees occasionally encroaching from the edges. Trees tended to be small and prone to falling potentially due to the waterlogged substrate – logs were common throughout the transect. Twig sedges (*Baumea articulate* and *B. rubiginosa*) and Large Rush (*Juncus procerus*) to 1.5 m dominated the swamp along with aquatic grasses present throughout (*Amphibromus neessii* and *Lachnigrostis filiformis*). Species diversity is relatively low but the swamp appears to be in good condition with little evidence of die-back and water present to the swamp margins when assessed in November 2014 and visited in March 20 15.

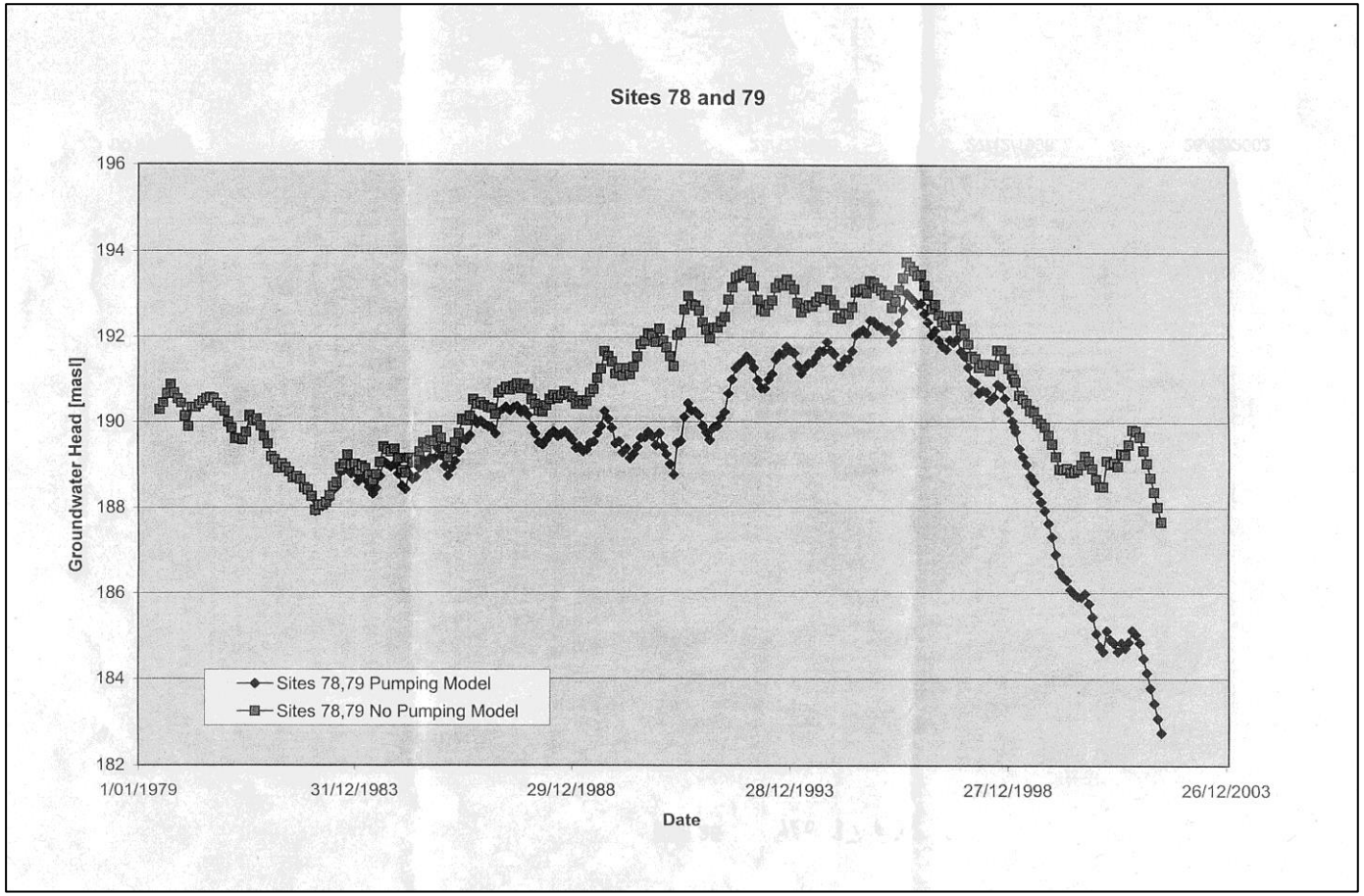
Vegetation Condition: In good condition – some falling Swamp Gums however this is more likely related to persistent water in the swamp rather than any lack of water availability

Evidence of Change: None observed

Notes for future monitoring rounds: This site is considered most likely to be linked to a perched aquifer and therefore could be an interesting reference site for future monitoring events once the hydrology is better understood.

10. Some extra comment on Vertical Leakage.

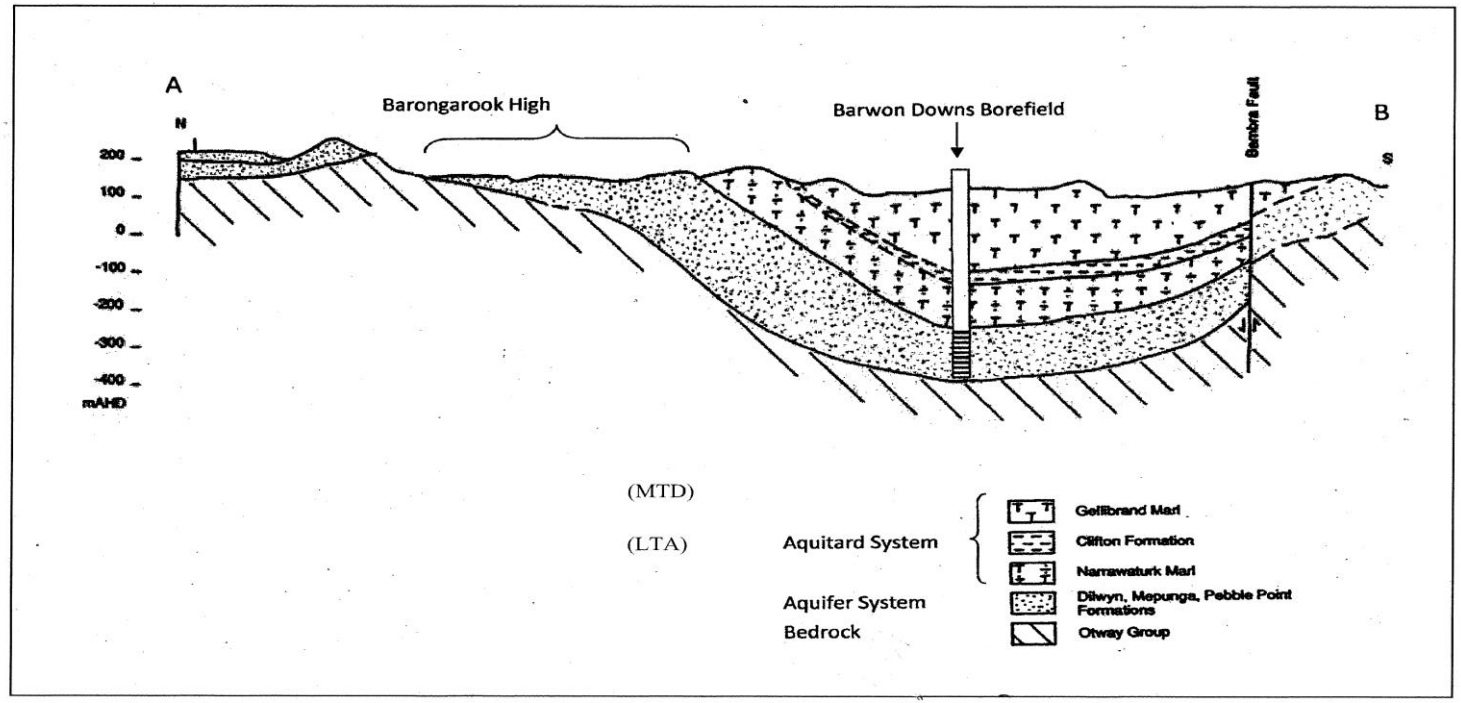
In 2003 this graph below was provided by Barwon Water by way of an FOI request (Barwon Water ref.FO73478). [67]



Site T3 is located in the same swamp as the 1994/2002 sites 78 and 79. This groundwater extraction hydrograph modelling shows the groundwater level to be 10 m lower in the TB3 observatrion bore than it would have been with no pumping. During the years not shown in this graph when the millenium drought took place, over 11 000 ML/year was extracted (see page 31). No analysis of the impacts

to this swamp has been done for the period December 2003 to September 2014. Also, it could be expected that a set of nested observation bores should have been drilled gauging the change in water level conditions at the various levels in the cross section through the swamp. Nested bores would go a long way to determining the exact status of whether the Boomerang Swamp is perched or not and whether there is any downward vertical leakage taking place. It is quite amazing that observation bore TB3 is over 200 m from the T3 transect in the swamp and at such an elevated site above the swamp. It would also be interesting to know which watertable observation bore TB3 is monitoring. Is it the Clifton Formation, the Narratartruk Marl or one of the watertable levels in the Lower Tertiary Aquifers? A better understanding how and where the Boomerang Swamp fits within this cross section would be gained using nested bore data.

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



SINCLAIR KNIGHT MERZ

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11. Vegetation Condition.

"***The current condition of the GDEs assessed does not suggest that a change in ecosystem function related to groundwater usage has occurred recently.***"

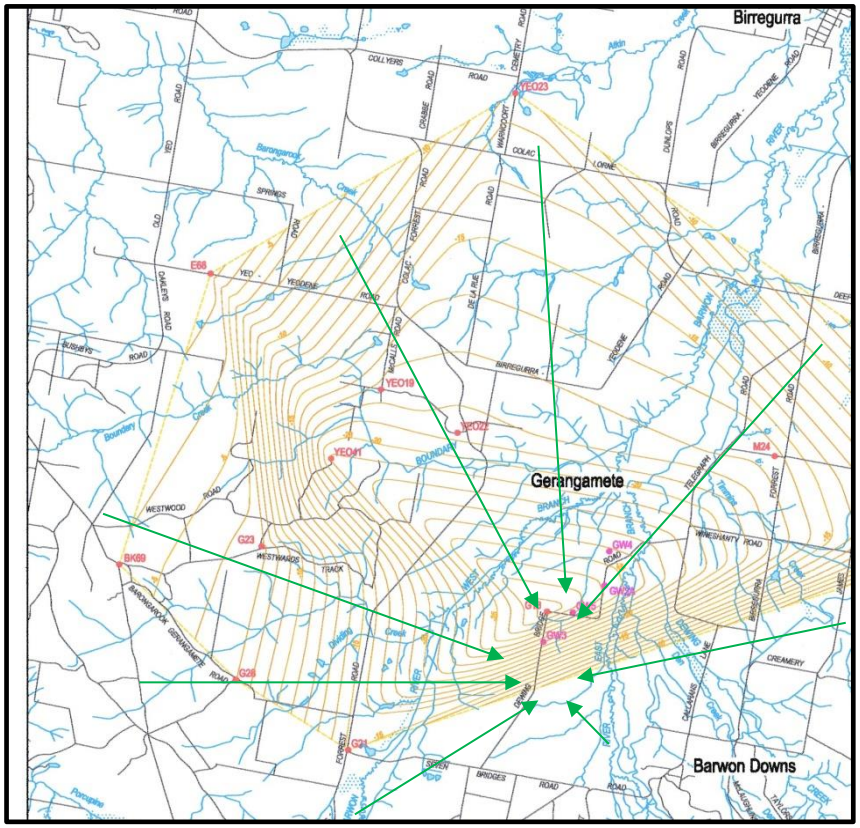
The 2015 report mentioned the decline in the new observation bores since installation with data going back 6 months.

"***The majority of bores show a gradual declined...***" No explanation was given for the decline and surely 6 months of observable data from bores measuring levels other than the level the groundwater is being extracted from, cannot be used to draw such conclusions.

To down play any possible ongoing impact occurring from the Barwon Down Borefield this statement was made.

"***No extraction of groundwater from Barwon Downs has occurred over this time and therefore this represents an environmental response.***"

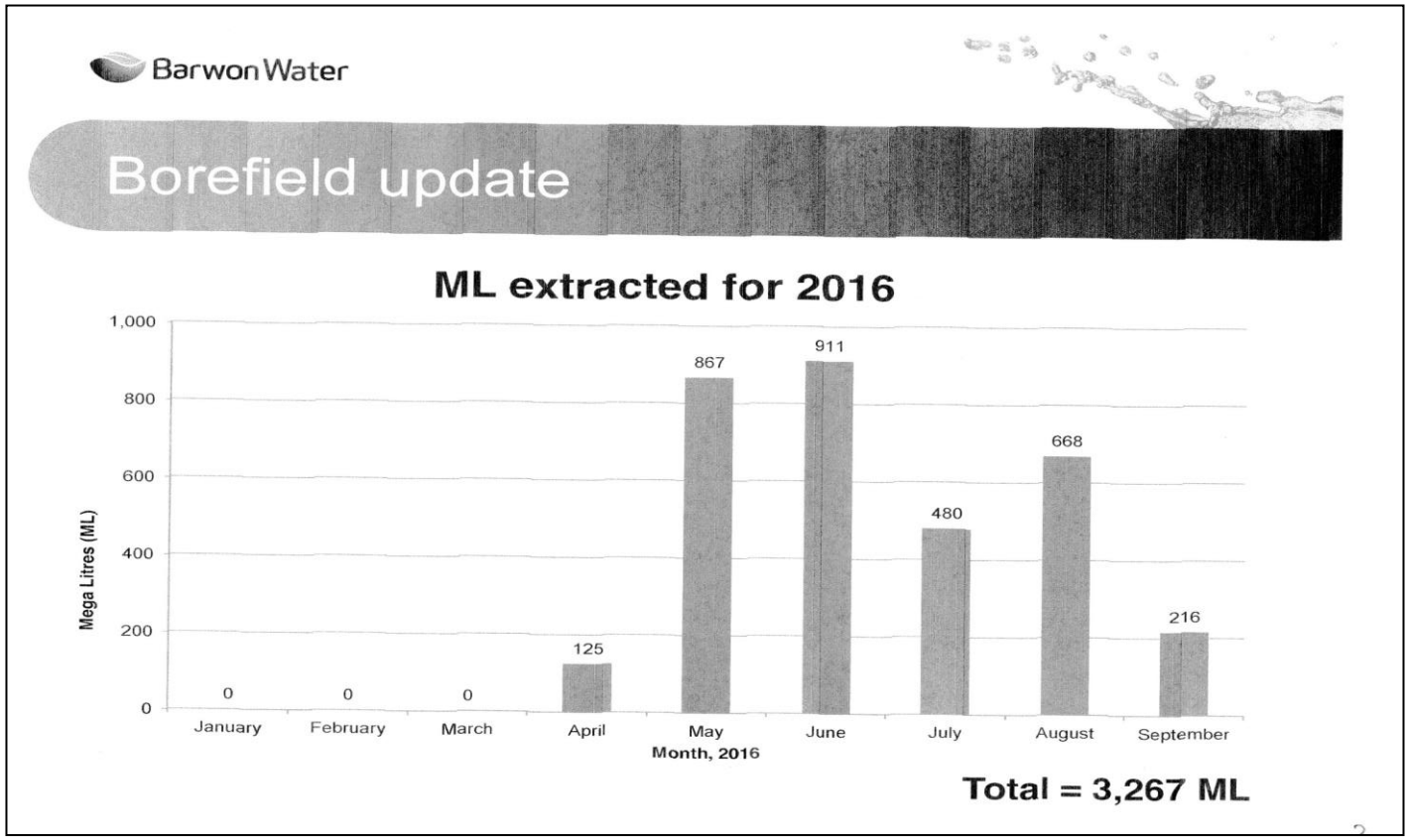
This statement shows a considerable lack of understanding how the impact still has a detrimental influence even after five years since groundwater extraction stopped in 2010. Firstly, no consideration was given to downward vertical leakage taking place as the depleted aquifer begin to fill the cone of depression, or the equalising effect as the cone of depression void sucks water in from all directions. Barwon Water's 2014-2015 annual report to Southern Rural Water still had the drawdown in the Pebble Point Formation at the borefield of minus 27 metres.



<u>MAP SOURCE</u>: Residual Drawdown Map from the 2014-15 report.

→ Direction of groundwater flow.

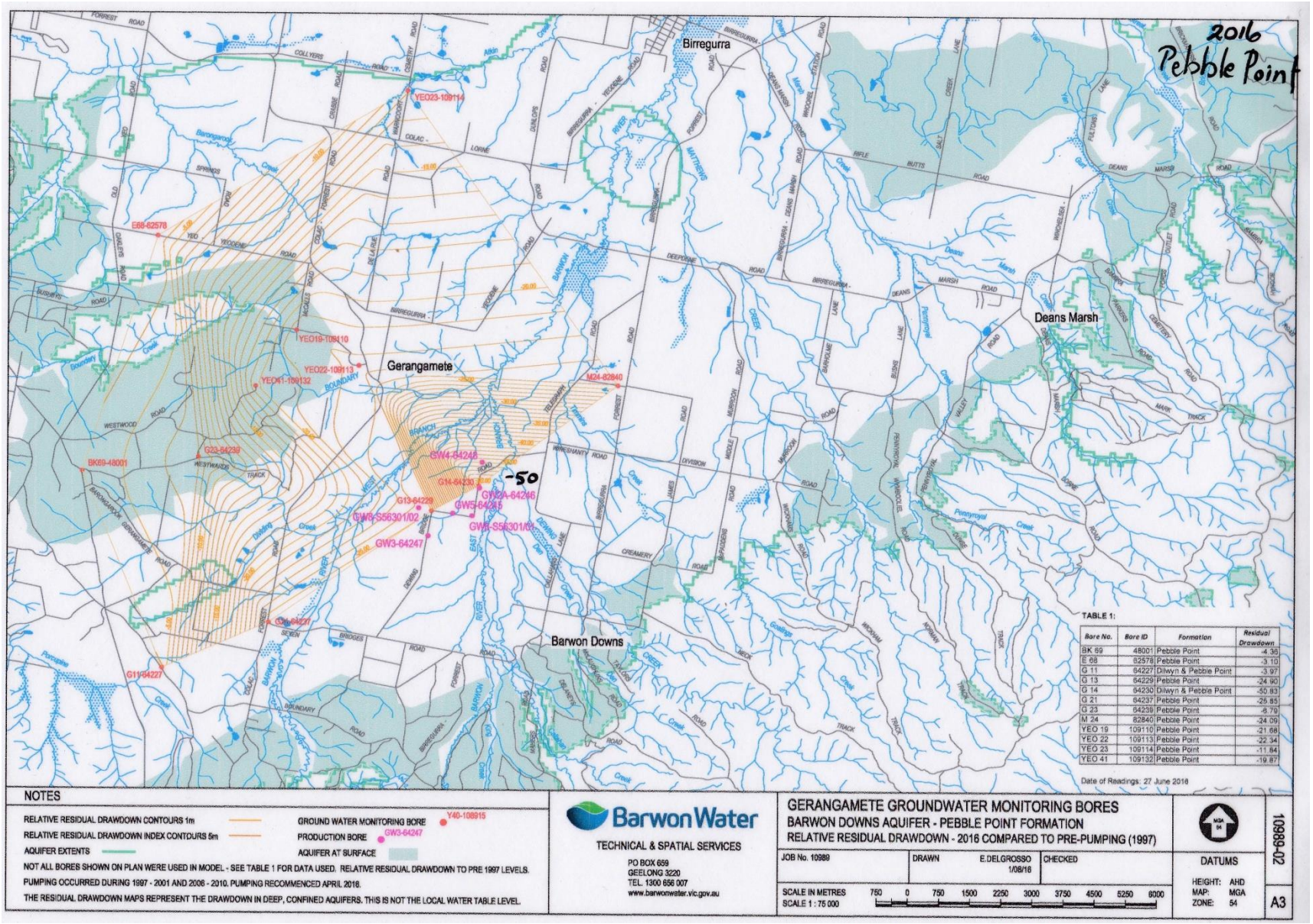
12. When the 2015 Jacobs report was finalised the Pebble Point Aquifer had recovered from minus 60 drawdown effect to minus 27 m by the end of June 2015. This Pebble Point recovery reflected what was also happening in the other two aquifers that Barwon Water was pumping from. Even though pumping had ceased years before the impact underground and at areas on the surface, would continue right up until the aquifers were fully recovered. Some forms of environmental impact would be slow to materialise. However, a compounding complication was thrown into this particular notion when in April 2016 the Barwon Downs Borefield was once again put into operation. By the end of June 2016 when the next Barwon Downs Borefield report was prepared, 1903 ML had been extracted from the borefield.



SOURCE: Barwon Water Groundwater Reference meeting Oct. 2016.

Quite amazingly this short period with just under 2000 ML being extracted, had a profound impact on the cone of depression in the Pebble Point aquifer.

The drawdown resulting from this small amount of water and over such a very short period resulted in a drop of 23 metres in the cone of depression in the Pebble Point Aquifer (see the next page, **124**).


2016
Pebble Point
Birregurra
Deans Marsh
Gerangamete
Barwon Downs
-50
YEO23-109114
E68-82578
YEO19-109110
YEO22-109113
YEO41-109132
M24-82840
BK69-48001
G23-64239
GW4-64245
G14-64233
GW2A-64246
G13-64229
GW5-64243
GW3-64247
G11-64227
TABLE 1:
Bore No. | Bore ID | Formation | Residual Drawdown
BK 69 | 48001 | Pebble Point | -4.36
E 68 | 82578 | Pebble Point | -3.10
G 11 | 64227 | Dilwyn & Pebble Point | -3.97
G 13 | 64229 | Pebble Point | -24.90
G 14 | 64230 | Dilwyn & Pebble Point | -50.83
G 21 | 64237 | Pebble Point | -26.85
G 23 | 64239 | Pebble Point | -6.79
M 24 | 82840 | Pebble Point | -24.09
YEO 19 | 109110 | Pebble Point | -21.68
YEO 22 | 109113 | Pebble Point | -22.34
YEO 23 | 109114 | Pebble Point | -11.84
YEO 41 | 109132 | Pebble Point | -19.87
Date of Readings: 27 June 2016
NOTES
RELATIVE RESIDUAL DRAWDOWN CONTOURS 1m
RELATIVE RESIDUAL DRAWDOWN INDEX CONTOURS 5m
AQUIFER EXTENTS
GROUND WATER MONITORING BORE Y40-108915
PRODUCTION BORE GW3-64247
AQUIFER AT SURFACE
NOT ALL BORES SHOWN ON PLAN WERE USED IN MODEL - SEE TABLE 1 FOR DATA USED. RELATIVE RESIDUAL DRAWDOWN TO PRE 1997 LEVELS.
PUMPING OCCURRED DURING 1997 - 2001 AND 2006 - 2010. PUMPING RECOMMENCED APRIL 2016.
THE RESIDUAL DRAWDOWN MAPS REPRESENT THE DRAWDOWN IN DEEP, CONFINED AQUIFERS. THIS IS NOT THE LOCAL WATER TABLE LEVEL.
Barwon Water
TECHNICAL & SPATIAL SERVICES
PO BOX 659
GEELONG 3220
TEL. 1300 656 007
www.barwonwater.vic.gov.au
GERANGAMETE GROUNDWATER MONITORING BORES
BARWON DOWNS AQUIFER - PEBBLE POINT FORMATION
RELATIVE RESIDUAL DRAWDOWN - 2016 COMPARED TO PRE-PUMPING (1997)
JOB No. 10989
DRAWN E.DELGROSSO 1/08/16
CHECKED
SCALE IN METRES
SCALE 1 : 75 000
750 0 750 1500 2250 3000 3750 4500 5250 6000
DATUMS
HEIGHT: AHD
MAP: MGA
ZONE: 54
10989-02
A3

13. The ANOV Analysis.

The ANOV statistical analysis presented in the Jacobs 2015 report concentrated on groundwater dependent species and groundwater dependent vegetation cover. The Jacobs report concluded that groundwater vegetation coverage surveyed would be sufficient comparison with future surveys. Irrespective of the species present, coverage by species would be used as the indicator of future change. However, only comparing groundwater dependent vegetation cover discounts species richness and or variability. This concentration on one aspect of groundwater dependent ecosystems seems to be very limiting. "***As the number of groundwater species at a site is not related to the relative performance of groundwater dependent lifeforms at the sites, both total and proportional has been used for subsequent tests.***" If concentrating on vegetation cover as a sole indicator of groundwater dependent vegetation health there is an extremely high probability of missing the true impact of any moisture change that may take place. For example: if the moisture levels were to drop below the normal variance, the highly sensitive groundwater dependent species will die out. Then, the more tolerant groundwater dependent species that can tolerate these drier conditions would prosper, filling the gaps. In this situation the vegetation cover would remain the same. Species change using the ANOV as presented would be regarded as insignificant and any drop in the watertable could be dismissed as inconsequential. Of course the opposite is also true. If the groundwater dependent ecosystem becomes wetter, the more tolerant water species will replace those species less tolerant to these conditions.

Species change should not be so easily disregarded as this is a very good indicator of groundwater change in groundwater dependent ecosystems. Future surveys must complete species comparison analysis.

Statistical analysis of vegetation coverage comparison alone would not give a true indication of the species variation, moisture level trends; or health and species richness, change and diversity within the groundwater dependent ecosystems.

14.The Review Process Conducted on the 2015 Vegetation Report.

This report has been scrutinised by 5 people before finalising the 2015 vegetation report - the author and four others including Barwon Water staff. How so many mistakes, discrepancies and unsubstantiated comments have "slipped" through this process is quite unbelievable.

This report also had to be submitted to Southern Rural Water as a condition of the 2004 groundwater extraction licence. By 26 May 2016 SRW had received the report on the 14 "modified" vegetation sites, and " ***... had no immediate concerns.***" (see Appendix 19, page **199**).

SRW also had this to say... "***We also had discussions prior to the assessment being done with DELWP and the CMA and recommended changes to methodology in undertaking the assessment due to some sites being questioned or located. I am pretty sure that we had this peer reviewed as well. SRW does not have experts in this matter.***" (see Appendix 19, page ***200***).

A follow up email 20 June 2016 arrived with this comment. "***In the end we didn't get a peer review of the report as we had both DELWP and the CCMA assist us in the process.***"

DELP was not asked what assistance it provided but the CCMA was. As at 13 July 2016 it would appear the CCMA had very little if anything to do with the 2015 vegetation report.
"***Just following up from your query regarding the change in sites for the vegetation study, what I have been able to find out is that this was Barwon Water lead project as part of their groundwater licence requirements, and approval was given by Southern Rural Water.***
The CCM has had no role in the vegetation study or the selection of sites, to find out more about why the sites moved and the process of approval you will need to follow up with Southern Rural Water as the approval authority." (see Appendix 19.)

These series of emails need no explanation or comment other than to remind the reader that the Barwon Water Groundwater Community Reference Group (CRG) was told in no uncertain manner that the Artificial Supplementary Flows could not be altered until the licence was reviewed in 2019. The licence conditions must be kept until the review process "kicked into gear." At the time a strong case could be made that the Artificial Supplementary Flows should be modified as soon as possible, not wait until 2019. At the same time that this discussion was taking place Barwon Water was able to have the vegetation sites in the licence conditions modified without so much as a "squeak."

Of particular note is that the planning and implementation of the 2014 changes to the licence conditions took place during the ongoing sitting period of the Barwon Water Groundwater Community Reference Group (CRG), and, at no stage had this Group been notified of the pending attempts and or the success at changes to the licence conditions. The first the Community Reference Group knew of these developments was after the finalisation of the 2015 vegetation report. So much for community input. Once again this is a case of the community most impacted having had no input until after the planning, implementation and finalisation of the development.

"Barwon Downs Borefield Tree Water Use Study in Barwon Downs." Prepared by SKM/Jacobs for Barwon Water.

At the same time that SKM/Jacobs was preparing the vegetation study as per the requirements of the Groundwater Extraction Licence, SKM/Jacobs was also carrying out a Tree Water Study for Barwon Water as part of the 2013/14 New Monitoring Program.
SKM/Jacobs presented some of the results of this study on 19 May 2015 to the Barwon Downs Groundwater Community Reference Group. The minutes of the May meeting were distributed in December 2015 and a presentation summarising the tree cover study was made available to the Community Reference Group on 3 December 2015.

The following material has been extracted from the May minutes and the 3 December 2015 presentation.

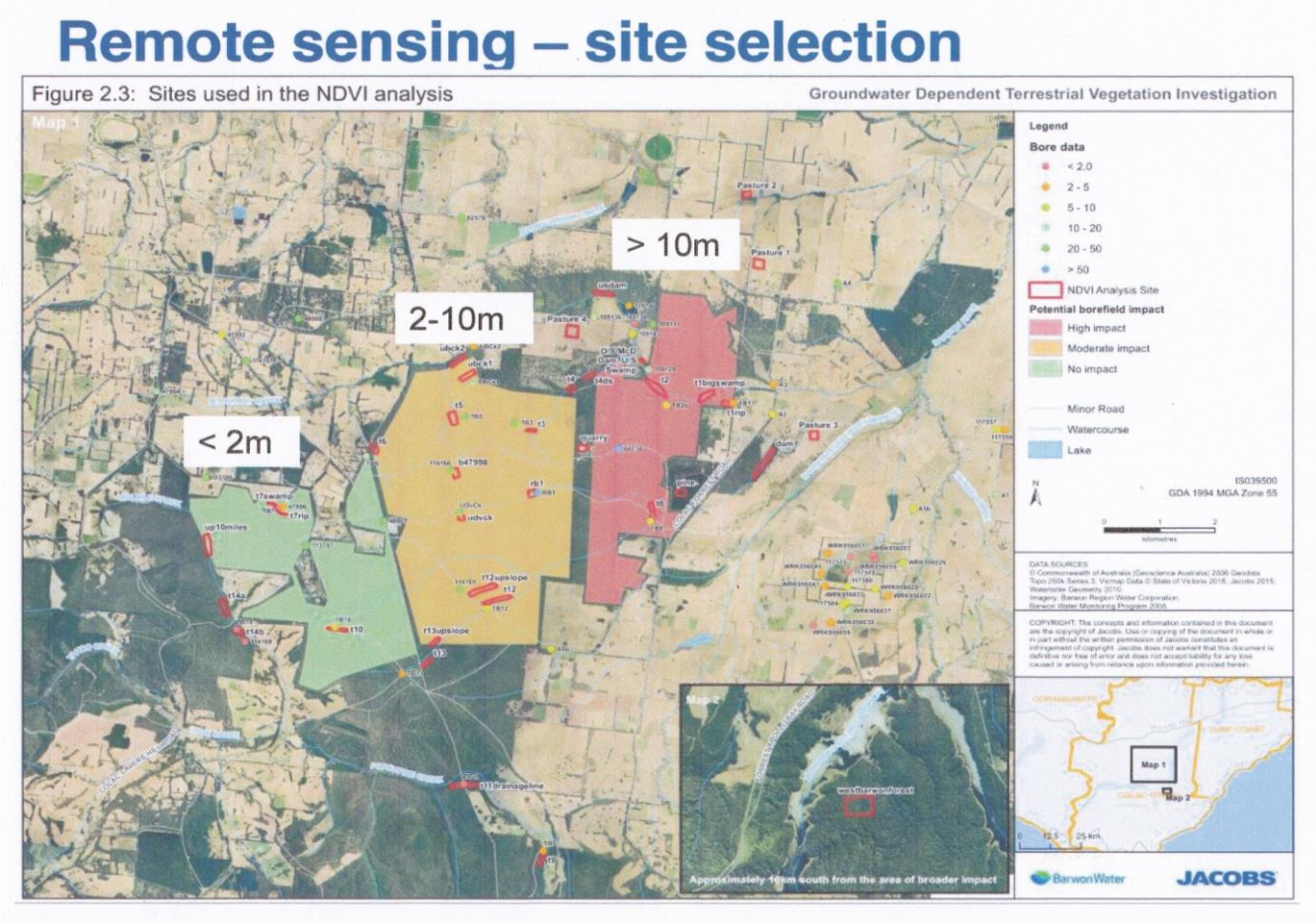
Two methods of investigation were used during the study.
The first method, NDVI (Normalised Difference Vegetation Index) provided a broad scale assessment of vegetation cover. The second method used involved drilling a bore taking a soil sample to test soil chemistry and soil suction.
The results included these findings:

- Virtually all sites plotted out in the range for healthy vegetation.
- Where the water table was shallow vegetation was doing better.
- There is no evidence in the NDVI results that groundwater extraction has had a negative impact on vegetation or condition.
- Groundwater use was generally considered minor or supplementary.
- Impact from groundwater extraction on vegetation suggests it is not an area of significant concern.
- Continued monitoring is important but does not appear to be an area of impact warranting significant concern.
- The NDVI broadly suggests vegetation conditions have improved closer to the borefield. The logical step being the borefield has not negatively impacted vegetation.

The area with potentially the highest chance to be negatively impacted from the borefield groundwater extractions (area coloured in pink on the map, page **128**), actually increased the most amount in healthy vegetation cover over the period of the study by **14%.**
The area of moderate expectation to be impacted (coloured yellow) also increased in healthy vegetation considerably, and the area furtherest from and expected to suffer the least impact, also increased in healthy vegetation cover but only by 5%.

- The increase in vegetation cover and especially the 14% closest to the borefield ***"could be discussed further in the report."*** As at 28 February 2017 a report has still not been made available.

- *"...evidence of burning off at some sites, including the control area, could be seen. While recovery from fire might explain a recovery in vegetation, it would get very complex trying to account for recovery from a controlled burn."*



- The report concluded that it was most probable that smaller species were using groundwater at a lot of the sites. Additional comment on this would be made in the report.

The 2016 Follow Up Vegetation Study, 19 September 2016.[121]

The establishment of a new baseline and fresh start with data collection at 14 "new" sites commenced in 2014, and eighteen months later these sites were resurveyed and reported upon. This report was prepared and reviewed by at least three personnel. Once again it is amazing so many mistakes could slip through this review process.

The decline in the vegetation condition since the collection of baseline data in 2014, was attributed to the last 12-18 months of dry conditions.

Some comments regarding this report.

1. Eighteen months is far too short a time frame for a vegetation study period to draw any significant conclusions.
2. The diagram on page 3 depicts the lowest reach of Boundary Creek as having a period when the creek is dry during non-pumping periods. This is true since the first serious pumping began in 1982, but for 72 years pre groundwater extraction, Boundary Creek did not dry up at all. This is another example of taking no notice of pre 2014 data.
3. The statement on page 6 that the groundwater extraction licence conditions protects stock and domestic use is strenuously denied by farmers along the lower reaches of Boundary Creek. Months of no flow down the creek is no form of protection of Stock and Domestic rights.
4. Page 6 also includes this statement... "***Ahead of the upcoming 2019 licence renewal process, Barwon Water instigated a technical works monitoring program to improve the comprehensiveness of the current program to ensure the submission of a technically sound licence application.***" Unfortunately the "current program" was scrapped for a new program, not improved upon. The fresh start vegetation surveys conducted between 2014 and 2016 may have been technically sound but scientifically such surveys require at least a 10 year research period. Ideally 30 years is required.
5. This transect diagram (see page **130**) of the Big Swamp or T1, and the accompanying description throws some doubt on the technical expertise of this report as well.

   "***The location of site T1 is shown in Figure 3-1. This site is located within the Big Swamp into which Boundary Creek flows and dissipates before reverting to a channel west of the Colac-Forrest road. Big Swamp is a peat swamp and the majority of peat was burnt intermittently between 1998 and 2010.***"

   The swamp first caught fire in 1997, was on fire again in 1998 and then in 2010. The 1997-98 fire was located in a very small section in the top end of the Big Swamp. This same area including the entire swamp, was burnt in 2010.

   Boundary Creek ***does not*** flow through the Big Swamp as this diagram depicts. The creek flows hard up against the rapidly rising topography to the forest along the northern boundary of the swamp. The only time water flows out of Boundary Creek and dissipates across the swamp is during high rainfall events. One only has to carry out the most basic of investigations to realise the mistake this Jacobs map (see below) has made.

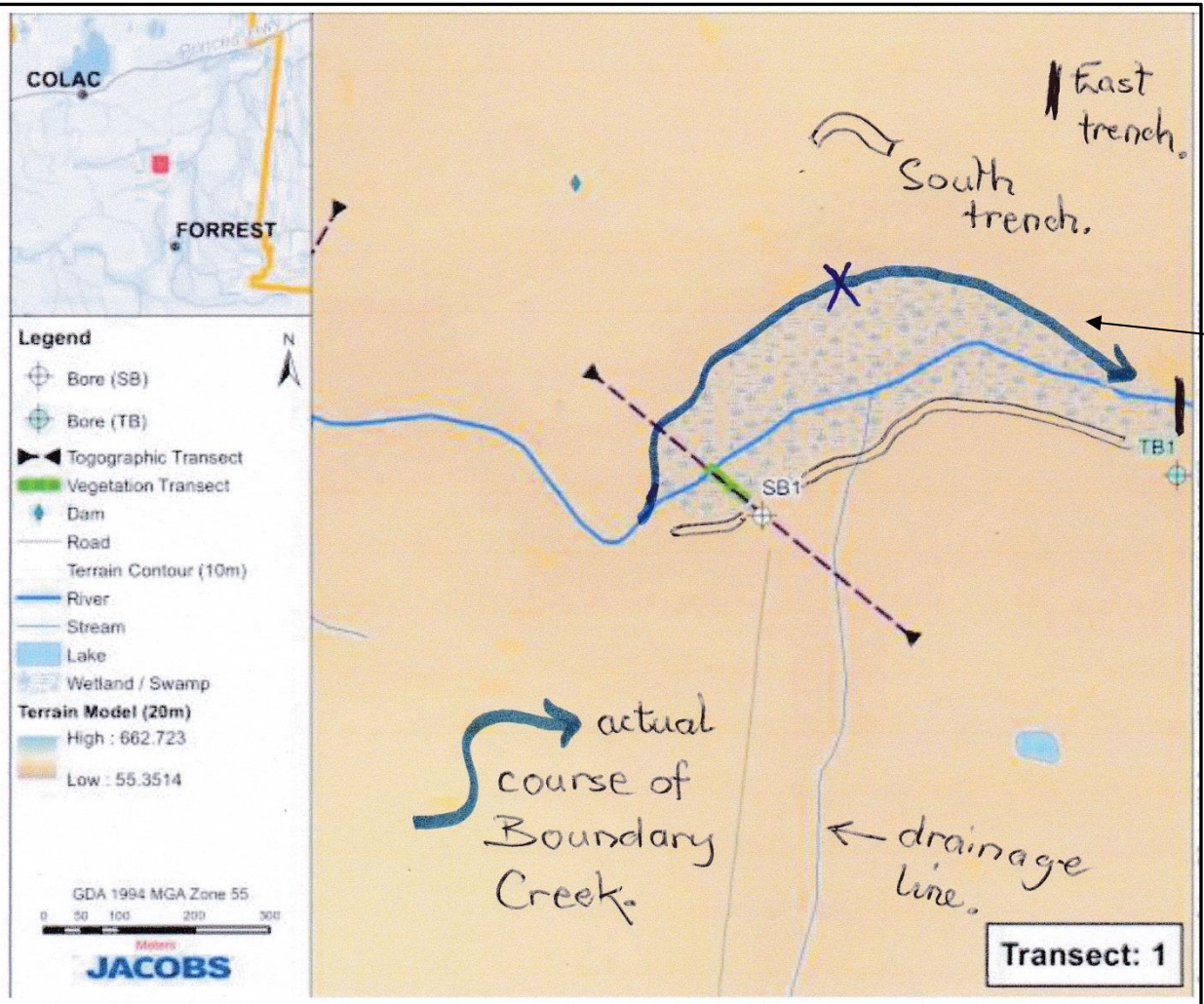
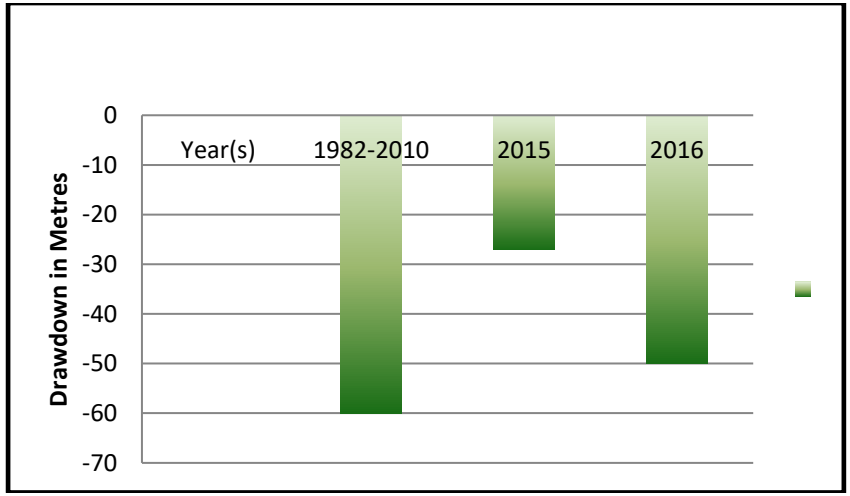


Figure 3-1 : Location of site T1

This dark blue line indicates where Boundary Creek actually flows. At no stage, other than under flood conditions, does water overflow into the actual swamp.

The path of Boundary Creek indicated through the swamp by the light blue line is incorrect.

6. "***To address community concerns...***" is a theme that is presented at various times throughout this report and gives the impression that community concerns have been addressed. This could not be further from the truth. The local community was not involved in the 2012 development document that set down the parameters of the new monitoring technical review program. Neither was it involved in the review of this 2012 document or the development of the final 2013 program. After the die had been cast a Community Reference Group (CRG) was appointed. It met for the first time in October 2013 long after the program was set in motion.
7. It is stated on page 9 that from 2014 "***The program is underpinned by scientific rigor using multiple lines of evidence-based techniques to establish the relationship between cause and effect for potential impacts caused by groundwater extraction.***" It is very doubtful that scientific rigor includes dismissing 30 years of data relevant to the cause and effect relationship.
8. Because the 2008 vegetation survey was reported by Barwon Water as inconclusive 14 "new" vegetation sites were established in 2014. "***The objective of this vegetation survey is to monitor the vegetation condition at each of the 14 monitoring sites to ensure there is adequate baseline information prior to use of the Barwon Downs borefield in 2016.***" A fresh start, a new baseline established and data collection dating from 2014.
9.



When asked at a Community Reference Group meeting in 2016 why the pumps were restarted in April 2016 especially when Geelong was on no water restrictions, the answer was, because we can. The licence allows Barwon Water to pump so it can at any time. No other explanation was given.

Since the millennium drought pumping had ceased in 2010, the Pebble Point Aquifer had recovered from a drawdown of 60 metres to 27 metres. After this groundwater extraction, April to the end of June, the Pebble Point Aquifer had dropped back down to 50 metres. A fall of 23 metres.

10. Jacobs have persisted with the following notion that... "***Reference sites were located in parts of the aquifers where no impact on water levels from the Barwon Downs borefield has been observed (or is expected to be observed under future pumping).***" It is confounding why Jacobs refers to these sites as reference sites when the groundwater extraction licence refers to them as control sites.

However, each of these control/reference sites is well inside the residual drawdown area of influence from the borefield, making it extremely difficult to argue from a scientific viewpoint, that they are indeed control sites.
It is true that under pumping conditions there may be no observable impacts but impacts can occur any time, even after pumping ceases and in fact may take decades to be observable.

11. Page 14 persists with the notion that only sections of the Big Swamp were burnt in 2010.
12. For some reason the numbering of the categories for the Functional Group Descriptions have been reversed. In pre 2014 surveys the most permanent water reliant vegetation was categorised as 1. The drier type vegetation was classified a level 6. In the reports since 2014 the most water reliant vegetation is classified as level 6. This reversal of categorisation can be slightly confusing.
13. Why Site T14 is being kept as a "***spare site***" when it is arguably one of the best "control" sites seems to make no sense.
14. This report states that 4 of the fourteen vegetation sites sit on perched swamps and as a result are not connected to the lower Tertiary Aquifers, and therefore are under no influence from the Lower Tertiary aquifers. Why these 4 sites were then chosen to be part of the modified licence conditions if they are not under the influence from groundwater extraction, is most difficult to understand.
    The reality of downwards vertical leakage continues to be ignored. Considering the scant data available on the formations from which downward vertical leakage would be taking place, it is most difficult to attribute below average rainfall as the major contributing vegetation declining factor.
15. Statements such as "***Given the borefield has not been used since 2010, this*** (any vegetation decline) ***is attributed to the below average rainfall conditions.***" discount any possibility that the massive drawdowns in the Lower Tertiary Aquifers, that are still in recovery mode, are having any impact. Yes pumping ceased in 2010 but the aquifers still have metres of recovery to go.
16. Considering the number of people involved in the processing of the Jacobs reports it is difficult to understand how basic mistakes can be made. Site T7 that is located on a tributary of the Ten Mile Creek close to 2 kilometres from Langdon's Road and is described as... "***Located at unnamed tributary of Boundary Creek on an unnamed access track off Landons Road ~ 400 m from turnoff.***"

There may well be other contentious statements contained in this document but what can be said is that from a technical and scientific point of view there is a lot to be desired.

1 December 2016 Jacobs Produced a Integration Report[122] re: the New 2013 Monitoring Program Implementations.

This Integration Report is reported as... "...***a summary of all technical reports completed over the 18 months up to December 2016***."[122]
Similar criticism of the 2014 licence conditions vegetation report and the 2016 follow-up vegetation report can be aimed at this Jacobs 1 December 2016 Final Integration Draft Report and is best summarised in the following dotted points:

- 18 months between vegetation surveys has limited scientific significance.
- There are at least 6 references scattered through this report reflecting the sentiments stated in the following three statements. "***There is no evidence that groundwater extraction from the Barwon Downs borefield has had a negative impact on vegetation activity or condition.***"
  "***No evidence was found that declining groundwater levels caused by groundwater extraction at Barwon Downs had a negative impact on vegetation health in the catchment.***"
  "***... there have been no vegetation health issues identified that would influence the licence renewal.***"
  It seems incredible that these statements resulting from two surveys over 18 months are put forward as the most informative and up to date analysis of impact on vegetation from the Barwon Downs Borefield. Using this limited data set to arrive at the conclusion there is no impact on vegetation from the borefield, will certainly have a strong influence on the outcome of the licence renewal process unless it is challenged.
- The statement "...***there have been no vegetation health issues identified that would influence the licence renewal.***" Is also similarly misleading. If one discounts the scalding of pasture from acid sulfate soils; the devastation caused in the Big Swamp and other hydrologically sensitive vegetation sites being compromised, then this statement could possibly be taken as reasonably accurate.
- "***...and no acid sulphate soil issues outside of Yeodene (Big) Swamp were identified that would influence licence renewal.***" seems incredible when two LAWROC Landcare Group members in 2014, escorted an SKM representative to two severe acid sulfate soil problems outside of the Big Swamp site, sites that were within the residual drawdown influence from the Barwon Downs Borefield.
- This report once again opens the discussion on perched aquifers being present within the area of the 2014 and 2016 vegetation study sites. Jacobs is suggesting there are now at least 4 of the 14 sites sitting on perched aquifers. It would also appear that there is an inclination to add the Big Swamp to this list of 4. Being such an important issue the notion of perched aquifers existing in the drawdown and vegetation site area, Otway Water Book 35 includes discussion on perched aquifers in the Yeodene area.
- Flathead Gudgeons have never been found in Boundary Creek. To say there is a chance they are present is pure speculation.
- The trenches dug at the Big Swamp were dug during the 2010 fire, not the 2006 peat fire. The site of the 2006 fire was located some 800 metres upstream of the Big Swamp. Also, this report does not mention that a mineral earth policy was developed around the site of this 2006 peat fire.
- "***a slow-burning peat fire at Yeodene (Big) Swamp.***" To include this as a definitive statement is also very misleading and sets in motion something that is close to an urban myth. It has not been established that the Big Swamp wetland was a slow burning peat fire between 1997 and 2010.
- The first sentence of this following statement is correct. However, the second sentence cannot be justified.. "***The peat swamp has experienced significant change over the last 30 years, including drying, fire and excavation of a trench to control fire. This combination***

has resulted in acidification leading to poor water quality in the creek downstream." The acidification had occurred solely from the peat being dried out. Fire and trenching came long after acidification and the release of heavy toxic metals.

- To state "***The stream flow gauges also show that Boundary Creek rarely stopped flowing during summer months prior to 1999, but since then has stopped flowing during periods in each summer.***" is also very misleading. If farmers who used to reply on a permanent continuous flow in Boundary Creek for stock and domestic uses are to be believed, then pre 1984 the creek did not dry up for any period. Platypus colonies, blackfish, native crayfish and other instream biota flourished pre 1984. Up to 50% of Geelong City's drinking water was pumped out of the ground during the 1982-83 drought and it has been since then that Boundary Creek began experiencing days of no flow.

  Neither does this statement explain that the correlation between the increase in groundwater extraction and an increase in the periods of no flow in Boundary Creek is exceptionally high. The periods of no flow downstream have increased dramatically and even 6 years after pumping has ceased Boundary Creek continues to have long periods of no flow throughout the year. Extraction impact continues.

  The diagram on page 2 Jacobs state Boundary Creek ceased to flow in 1990. This is directly after the 1986-1990 stress test pump. Also, the creek did cease flowing for periods after the 1982-83 drought extractions.

This 2016 Report is a summary of many of the technical reports compiled in this new monitoring program developed by Barwon Water. Unfortunately many of the actual reports have been difficult to obtain or have not been made available as at March 2017.

CONCLUSION

It would appear that the relationship between groundwater extraction at the Barwon Downs Borefield and impacts on sites of hydrological sensitivity within the area of drawdown influence from this borefield, will never be solved if Barwon Water is left to make the determination.

In 1986 after Quentin Farmar-Bowers had completed his task of outlining the investigations required to establish baseline environmental data, Barwon Water stated in 1988 to the Natural Resources Environment Committee, that this data had been collected. This was not the case. It took another 5 years before a service contract was prepared by Barwon Water to investigate and collect baseline data on flora and fauna in the areas of possible drawdown impacts from the Barwon Downs Borefield. Barwon Water was preparing its case for a groundwater extraction licence application.

The brief given to Ecology Australia for the 1994 flora survey could not have been any more specific - find sites of hydrological sensitivity and record the vegetation that is found within these areas. This task was completed by Ecology Australia and excellent points of reference were established creating a baseline data set to be used for future comparison. Knowing that there would have been follow-up surveying of sites, site co-ordinates were recorded. The extraction licence was granted. To gain a true understanding of the relationship between groundwater and hydrological sensitive vegetation sites, the 1994 flora study recommended that Barwon Water put in observation bores at each vegetation site. When installing these monitoring bores the accuracy of the map co-ordinates for each site could have been verified. However, none of the recommendations were implemented and when attempting to relocate the sites in 2002 some of the map co-ordinates were found to be lacking.

Not until leading up to the renewal of the groundwater extraction licence, was any further work carried out. In 2001 Ecology Australia was asked to conduct a re-survey of hydrological sensitive vegetation sites they discovered in 1994 in an effort to determine whether changes had taken place. 34 sites of the original 82 were chosen. Significant changes were noted at several sites. Once again recommendations from this work were made to ensure continuity, accuracy and appropriateness of monitoring, but unfortunately once again they were not implemented.

A licence for 20,000 ML/year extraction was granted despite the data indicating that hydrological changes were taking place and a Permissible Annual Volume of extraction had earlier been established at 4,000 ML/year, maximum. Despite these things, it was recognised that impacts were taking place and an attempt appeared to be made to build on the earlier work of Ecology Australia by continuing the vegetation monitoring. The 2004 groundwater extraction licence conditions stipulated that 8 control and impact sites were to be surveyed every five years.

In 2008 when Ecology Australia was conducting the first of these five year surveys, they visited and placed permanent galvanised droppers at many of the water sensitive sites established during the 1994 and 2002 surveys. However, not all of these sites were included in the 8 control and impact sites of the 2004 licence and consequently were not written up in the 2008 report. Unfortunately, Southern Rural Water had failed to keep a written promise to include, as an extra site, the heavily impacted and devastated Big Swamp Wetlands in the 2008 Study. Ecology Australia did visit the swamp and marked it with a galvanised dropper but no record of this visit has been released.

By 2008, when the first of these 5 year vegetation surveys was conducted, subtle but significant changes had taken place. Ecology Australia efforts were no longer totally independent, coming under the guidance of SKM. As stated above the licence review process completed in 2004 had determined that eight vegetation sites were to be surveyed but unfortunately the 4 control sites fell well inside the residual drawdown impact from the Borefield. Scientifically these sites could not be classified as control sites. Even so, for some reason the best of the control sites was not even used for comparison with other sites as one would have expected.

The objectives as outlined by Farmar-Bowers, way back in 1986 and begun by Ecology Australia in 1994 and 2002, supposedly still had not been achieved in the 2008 survey. Barwon Water summarised that conclusive results could not be determined from this 2008 or earlier reports. Amazingly, once again no follow up work was commenced until 2012 when the second of the five year vegetation surveys was coming due in 2014. The licence renewal date was also approaching.

In 2013, in the lead up to the 2015 vegetation survey the "goal posts" shifted once again. Barwon Water convinced Southern Rural Water to agree to a totally new approach to hydrologically sensitive vegetation monitoring. Even though the Barwon Water Groundwater Community Reference Group (CRG) was meeting when these changes were being made, no community consultation was called for at the development or implementation stage. In fact it was made quite clear that these discussions were not part of the CRG's mandate. In hindsight this seemed extraordinary considering the vegetation studies when completed were referred to the CRG for confirmation. During the same period that the vegetation licence conditions were being changed the CRG requested that changes to the releasing of the Artificial Supplementary Flows be considered. The CRG was told any changes were not possible until 2019 when the licence was up for renewal. Any changes could not be made until 2019. However, at this very same time Barwon Water was lobbying Southern Rural Water to change the vegetations sites stipulated in the 2004 licence.

In 2014 the licence conditions were changed and 14 "new" sites were renamed and called new sites; new sites in close proximity to old sites were named as new sites; totally different new sites were chosen and co-ordinates of the fourteen 2014 vegetation survey sites were

confusing and in many cases incorrectly recorded. Throughout the period from 1986 to 2014 vital follow up work implementing recommendations and collection of data was not done and the data that had been collected during this period was discounted in the 2014 work. The 2014 study herald a new start and once again a new reference or baseline starting point was established. The "goal post" had shifted once again and by 2016 the claim was being made that there was no evidence of impact on hydrologically sensitive vegetation sites as a result of groundwater extraction at the Barwon Downs Borefield. No reference was made of the fact that this assertion was only based on 18 months of data collected since 2014.

The 14 "new" sites chosen were identified as sites with supposedly hydrologically sensitive vegetation with moisture levels sustaining Groundwater Dependent Ecosystems. Control sites were once again chosen within the area of drawdown influence from the Barwon Downs Borefield and Jacobs placed a subtly different meaning to these sites referring to them as reference sites. Site T3, an original site was dropped from the third survey in 2008 as not being connected to the borefield influence, sitting on a perched swamp. However, in the 2008 survey it was stated there was no evidence to support the notion of perched swamps at this site. Then unaccountably, this very same site is reintroduced as one of the "new" 2014 sites, and then, is once again discounted as important in any further studies as it supposedly sits on a perched swamp with no influence from the borefield.

To make matters worse, arguably the best control/reference site chosen in the 2014 "new" sites is in future to be kept in reserve at follow up surveys and only used if for some reason one of the other chosen sites becomes unavailable.

Any impact that had been caused by the Barwon Downs Borefield for the previous thirty years of extraction was relegated to the history books and a new era of technical and scientific expertise came to the fore. There was an apparent urgency to prepare a case for licence renewal. Ignoring past history and relying on 18 months of vegetation study, cannot be justified as scientifically robust. Failing to meaningfully involve the local community most affected ignores the power of social licence and the ability of people from the community to critically scrutinise and analyse scientific and technical reports. However, what is of bigger concern is the lack of ability by Jacobs and Barwon Water to recognise and embrace any self appraisal as a result of this scrutiny.

On analysis these latest SKM/Jacobs reports prepared for the Barwon Water 2019 licence renewal process have been found to be seriously lacking.

- There has been little if any independent peer review of work
- Confusing and incorrect map reference and locations given
- Site location descriptions grossly incorrect

- A lack of recognition to the concept and impacts from downward vertical leakage
- Dismissal of historical data
- Dismissal of historical local data
- Inaccurate flowpaths of Boundary Creek
- Assertions based on extremely short periods of research
- Inability to self appraise
- Inability to correct the most basic of mistakes when made aware of the mistake.

On more than one occasion access to documentation of relevant reports and data had to be obtained through the very lengthy and costly Freedom Of Information process. Lack of transparency and openness have been strategically limiting.

Finally, three things are abundantly clear:

1. There is sufficient data, reports and local knowledge available to conclude that the drawdown from the Barwon Downs Borefield has had significant detrimental impact on Groundwater Dependent Ecosystems.
2. Ignoring 30 years of data by establishing a new database timeline starting from 2014 and then drawing a conclusion 18 months later stating that... "***There is no evidence that groundwater extraction from the Barwon Downs borefield has had a negative impact on vegetation activity or condition***." is far from scientifically or technically sound.
3. Little credence can be placed upon studies that lack independent peer review; contain gross inaccuracies and do not follow scientific rigorous processes.

"The new monitoring program will increase understanding of the Barwon Downs groundwater system in its normal state."

(SKM 2015)

"***No evidence was found that declining groundwater levels caused by groundwater extraction at Barwon Downs had a negative impact on vegetation health in the catchment.***"

(Jacobs 2016)