

**OTWAY WATER BOOK 16**

**COAL SEAM GAS  
IN THE OTWAY  
RANGES &  
DISTRICT.**

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**Malcolm Gardiner**

**September 2011**

The exploration & extraction of Coal Seam Gas in the Otway Ranges & District will only exacerbate and compound the detrimental impacts to the social, environmental and economic structures of the area already created from unsustainable groundwater extraction.

**NOTE:** Notation such **(B10P5)** indicates referenced and supporting material can be found in “Otway Water” Book 10, Page 5 as a free download at [www.otwaywater.com.au](http://www.otwaywater.com.au)

**NOTE:** The Bibliography for this Book is found on page 21.

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**September 2011**

Malcolm Gardiner

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Saturday Age article in the Good Weekend, *“What lies beneath”* by David Lester, page 16, August 13, 2011, the Queensland experience.

***“ You can’t keep on taking water out and not have something happen under the ground. The mining and coal seam gas industries are doing whatever they want. We’re being attacked from all sides.”***

And on the front cover of this edition of the Good Weekend,

***“ I cried for two days. Then I got angry.”***

And so the rear guard action in Queensland begins.

It would appear that the action is just beginning in Victoria and if so should Victorians be crying or getting angry first?

## INTRODUCTION

A common factor in all Coal Seam Gas extractions where there is an aquifer involved, as in the Otway Ranges & District, is the utilisation of huge amounts of water. For a resource that is already fully allocated and in most instances over allocated, the introduction of Coal Seam Gas (CSG) into the equation spells disaster on a massive scale for the Otway Ranges & District. The multitude of risks and impacts peculiar to Coal Seam Gas extraction does not bare thinking about.

A Coal Seam Gas exploration licence has been issued by the Department of Primary Industries, State Government Victoria, for the Colac and Otway District Area (see map on page 7). Licences have also been applied for that cover the Corangamite, Mortlake, Warrnambool, Portland and Nelson map areas.

The risks and detrimental impacts that Coal Seam Gas extraction inflicts upon social, environmental and economic values are many, and well documented. So much so that France came to the realisation that Coal Seam Gas extraction had to be banned. Moratoriums are presently in place in South Africa, Quebec, New South Wales, New York State, New Jersey and Pennsylvania. It is also extremely well documented in Queensland that Coal Seam Gas extraction has a raft of detrimental impacts.

In the Otway Ranges & District and particularly in the Upper Barwon River, the Loves Creek and the Gellibrand River Catchments, the ground and surface waters have already been over allocated. Simply put, even before any Coal Seam Gas extraction takes place, there is insufficient water to meet present demands, especially in dry periods of high need.

As a consequence of this over allocation of the Otway Ranges' water resources,(B14)

- Streams have been dried up and cease to flow,

- Wetlands and water dependent ecosystems have been decimated,
- Farming enterprises have been compromised,
- Toxic amounts of acid and heavy metals have been produced polluting streams and aquifers,
- Stygofauna (groundwater life forms) has been placed in jeopardy,
- Fire intensity, duration and threat have increased incalculably,
- Volumes of carbon have been released into the atmosphere,
- Subsidence has taken place,
- Corrosion of infrastructure is a reality,
- Recreational pursuits and safety compromised, and
- Toxic gases produced.

## CONCLUSION

A moratorium must be placed on all Coal Seam Gas exploration and extraction in Victoria until lagging and outdated State Government Legislation catches up to such a stage that social, environmental and economic safeguards have been put in place.

However, if present ground and surface water extraction practises and management are any indication, this will never happen. The State Government authorities are incapable of enforcing present policy, legislation and safeguards regarding groundwater in the Otway Ranges, so it is extremely doubtful that new legislation would be any more effective.

The only safeguard with any chance of protecting the Beneficial Uses (B10P91)(see page24) of life in the Otway Ranges & District is to ban Coal Seam Gas exploration and extraction completely.

In the foreseeable future there is no place for CSG extraction in the Otway Ranges or District.

This book supports and advocates the argument that there can be no compromise on this stance.

## Are the Victorian politicians aware or even concerned about Coal Seam Gas exploration in our State? It appears not.



26 August 2011 on 7:30 Vic.

MP Peter Walsh, Minister for Water and Agriculture (Victoria) had this to say regarding Coal Seam Gas, *“Well, as far as I am aware there is no proposal for Coal Seam Gas here in Victoria.”*

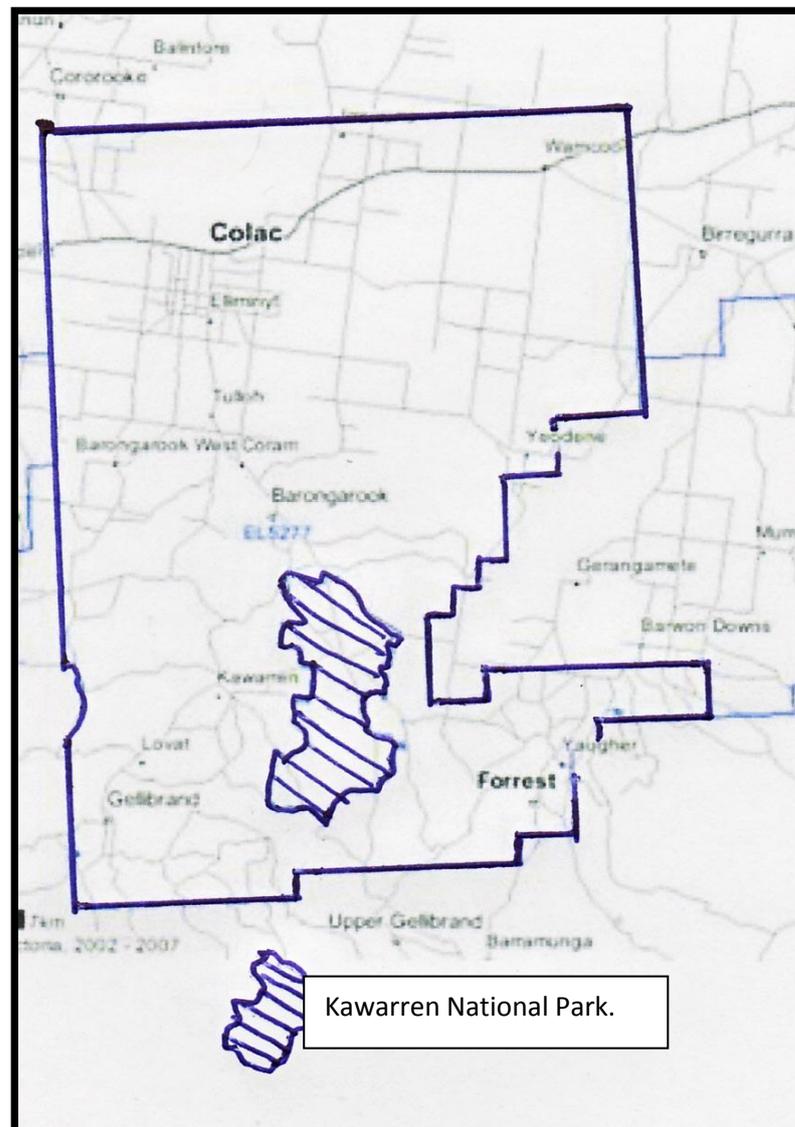
It is most obvious that Minister Walsh is not aware that his State Government of Victoria issued a five year licence to ECI International in December 2010 allowing Coal Seam Gas exploration in the Otway Ranges, Victoria (see page 23).



26 August 2011 on 7:30 Vic.

In the same ABC programme the Premier of Victoria, Ted Ballieu, had this to say about Coal Seam Gas after the program announced that the State Government recently issued permits to Summerton and Beach Energy to explore for Shale Gas over 2000 square kilometres of a prime farming region of the Western District.

*“We haven’t had a, a big issue with it (Coal Seam Gas) here, uh, and as I say we don’t currently have any proposals to change the laws.”*



This map shows the area being investigated under Licence 5277 (see appendix 2). The Kawarren National Park is excluded from exploration.

## Coal Seam Gas.

The mixture of gaseous hydrocarbons being sought in most coal seams or coal beds, is in general terms defined as methane (CH<sub>4</sub>). Methane is generated from a biological process as a result of microbial action and or from a thermal process as a result of increasing heat with depth of the coal.<sup>(3)</sup>

## Victorian Coal Seams.

*“Whilst most of Victoria’s coal resources is well known the amount of associated methane is uncertain. Much of this coal lies at shallow depths, making testing and extraction inexpensive.”<sup>(1)</sup>*

*“Coal seam methane is classified as a renewable energy source under the Commonwealth renewable Energy Electricity Act 2000.”<sup>(1)</sup>*

*“Most of this (methane) is absorbed onto the coal surface, the remainder exists as free methane in the natural fracture (cleat) system of the seams or is dissolved within the seam water.”<sup>(1)</sup>*

In Victoria exploration licences are generally for 5 years. Extraction licences are usually for 20 years. Once issued licences are almost invariably never modified or reviewed until the licence expires. For this reason licences should not be granted until appropriate guidelines and safeguards against unacceptable social, environmental and economic impacts are put in place. The implementation of the “Precautionary Principle” as outlined by the State Government should be applied in this situation(see page 16).

## Methane Locked in Aquifer Water.

Methane lies in pores and cleats in the coal seams and is trapped there by water. Extracting the groundwater reduces the water pressure that holds in the gas. Methane being a low soluble gas in water will readily separate as the water pressure reduces.

## Fracking.

In some CSG operations a process of fracking is employed. This involves fracturing or opening up of and holding the fractures open in the coal seam allowing the methane to be readily released. This process requires the use of large quantities of water and fracturing fluids which are injected underground at high volumes and pressure.

Once the seams are fractured and kept open these fluids are removed relieving the pressure allowing the methane to escape and be collected at the surface. Unfortunately not all of the fracking fluids are able to be removed.

## **Known Impacts & Risks from Fracking and Extraction of Coal Seam Gas.**

1. Inadequate or outdated legislation protecting landholders and Beneficial Uses.
2. Gas leaks and explosions.
3. Extraction of the methane involves pumping large volumes of groundwater from the saturated coal seams in order to release the water pressure holding the methane in the coal seam. In the short and long term this can cause streams, springs and water dependent ecosystems to dry up.
4. The Otway Ranges streams that flow all year are groundwater dependent. There are several examples where urban groundwater extraction has caused streams to cease flowing in periods of low rainfall (**Books 1-14**). CSG extraction will only exacerbate this.
5. Chronic over allocation of water resources is a certainty. The water resources of the Otway Ranges are presently at best, fully allocated.
6. Compared to the surface waters, the extracted groundwater is heated, low in oxygen, high in hydrogen sulfide and acidic, at levels not experienced by the biota in the surface water. The disposal of this water into streams will cause severe problems for instream and water dependent ecosystems.
7. The natural state of the groundwater can be dramatically altered putting at risk the sub-terrestrial fauna known as stygofauna.

8. Some of the fluids and materials injected into the ground during the fracking process are a serious concern. A Congressional USA committee investigated the practices of 14 fracking companies for the period 2005-2009 and made these findings,<sup>(5)</sup>

- ***“This report shows that these companies are injecting millions of gallons of products that contain potentially hazardous chemicals, including known carcinogens.”***
- More than 780 million gallons of hydraulic fracturing products used.
- ***“...over one and a half million gallons of carcinogens were injected into the ground in Colorado.”***
- 2500 hydraulic fracturing materials used.
- Containing 750 chemical compounds.
- 652 of these products contained 29 chemicals that are known or are possible human carcinogens.
- In 95 products 13 different known carcinogens were used.
- 10.2 million gallons of fracturing products contained at least one carcinogen.
- 11.4 million gallons of products containing at least one BTEX compound – benzene, toluene, xylene and ethylbenzene.
- A BTEX compound appeared in 60 of the hydraulic fracturing products.
- 279 contain *“proprietary or trade secret”* components of additives that were not named.
- Many companies using these chemicals have no or little idea of the chemicals involved. They purchase chemicals *“off the shelf”* to do a specific task and haven’t asked what they contain.
- A cocktail of chemicals are used performing various tasks – thickening and thinning fluids, improvement of fluid flow, killing of bacteria etc.
- ***“Each hydraulic fracturing “product” is a mixture of chemicals or other components designed to achieve a***

*certain performance goal... Some oil and gas service companies create their own products.”* The manner in

which this mixing of chemicals is done is not regulated.

9. These chemicals can then enter the stock and domestic water supplies.
10. The processes and outcomes involved with the chemicals injected into the earth may be understood, although this is doubtful, the effect on the microbial and other stygofauna is totally unknown.  
The fact that the stygofauna present in the Otway Ranges aquifers has never been studied is a glaring omission. Informed management decisions cannot be made when vital data and information such as this is missing.
11. When the hydraulic fracturing chemicals are extracted, though a substantial amount remains underground, the disposal of these waste materials becomes a serious problem because of:
  - spills,
  - leaching into the soil and other aquifer systems,
  - injection into underground storage wells,
  - discharge to surface waters,
  - transport to treatment plant facilities, and
  - the ability of treatment plant facilities to process the hydraulic fluid materials being doubtful and or expensive,
12. Well failures could lead to the leaching of the hydraulic fluids into other shallower aquifers.
13. The chemicals and processes used in fracing are not regulated.
14. When and if regulation catches up with the licences issued, if past experiences are any indication, these licences will be allowed to run the period of the licence. By this stage untold impact and damage will have taken place (20 years before review).
15. Due to little or no regulation, disclosure and collection of data, there is no effective means of assessing and evaluating

any short or long term impact the use of fracking fluids and methods may have on the environment and or public health.

16. In fact regulation and enforcement as it stands, can assist exploration companies to carry out their activities in relative freedom from scrutiny or regulation.
- 17.



A question asked but not answered on this show, was what happens when the impacts don't materialise until 30 years after CSG extraction commences. Probably more importantly is the question who would be held responsible especially if the extraction company goes "pear shape," changes its name or is sold off. Without safe guards including a substantial bond the environment and local community, both Beneficial Uses, would be considerably disadvantaged. Holding a company accountable would be almost impossible to attain.

18. An **Australian Federal Water Group** has these things to say about Coal Seam Gas in Queensland.<sup>(2)</sup>
- Detrimental impacts could present throughout the life of the projects - in the order of 30 years. Impacts could continue for an extended period after the completion of the projects
  - The companies involved are unable to accurately quantify their individual and collective impacts over the life of the projects
  - There is a potential for significant impacts
  - The volume of groundwater to be extracted is of serious concern regarding:
    - the structural integrity of the groundwater systems,
    - the change in pressure and volume impacts on the aquifers,
    - changes in water chemistry,
    - mechanisms for the disposal of water produced,

- impacts on surface water hydrology,
- land subsidence,
- impacts on highly productive agricultural land,
- impacts on indigenous cultural and spiritual values,
- impact on aquifers above and below the Coal Seam Gas activity level,
- the cumulative impacts,
- the impacts on an already stressed aquifer system,
- the impacts of decreasing the water static pressure across the project area,
- the possibility that springs systems within 50 km radius will be significantly impacted by cumulative drawdown effects,
- the projects are based on inadequate and sparse data,
- the fact that material presented by the companies does not match known facts,
- impacts that will occur in major flood episodes are not known,
- the discharge and control of salts and heavy metals being inadequately catered for,
- aquifer divides shifting will create unknown changes and impacts,
- groundwater pressure heads will be lowered by 400 metres over most of the area,
- the impact of establishing a de-pressurised zone between two pressurised systems is unknown,
- the difference caused in pressure causing previously “sealed” faults and fractures to become more open resulting in increased groundwater flow between formations is a distinct possibility,
- vertical leakage between aquifers becoming a distinct possibility,
- water resources that are already fully allocated,

- recovery from CSG production not starting until 70 years after gas extraction is finished is a reality,
- extraction companies having estimates that recovery may take up to 200 years in one area but up to 1000 years in another is alarming, and
- land subsidence that has already resulted in a drop of several metres in some areas of the CSG extraction projects is a fact.

19. Lack of base data is a serious problem. LAWROC Landcare Group has conducted a preliminary Total Water Balance for the Loves Creek Catchment (see pages 25-63). This is the only one known to have been conducted in the Otway Ranges. Sound management cannot be conducted when there are gaping holes in the data base. Lack of Total Water Balance studies is one such “black hole.” A Total Water Balance (TWB) is like preparing an account of “ins” and “outs” of the water resource. In the Loves Creek TWB it was found that the “outs” far outweigh the “ins,” indicating there is an over allocation of the water resources available.
20. Urban water extraction of groundwater has created an Actual Inland Acid Sulfate Soil (AIASS) site in a creek wetland, resulting in extremely elevated acid and heavy metal levels. These pollutants have then flowed back into the depleted aquifer and down surface streams. The possibility of numerous other Potential Inland Acid Sulfate Soil sites being impacted is extremely high (B14).
21. Drying out of wetlands in the Otway Ranges creates serious fire scenarios(B15PP1-40):
- the wetlands become highly combustible,
  - are subject to spontaneous combustion,
  - once alight can burn deep underground for decades,
  - provide an ignition point on days of fire danger, and
  - are extremely difficult to contain.

22. The **National Water Commission (Australia)** has issued a Position Statement on Coal Seam Gas and Water and contains these items.<sup>(4)</sup>
- If not adequately managed and regulated risks associated with CSG can be significant, long-term with adverse impacts on adjacent surface and groundwater systems
  - The cumulative effects of multiple projects are not well known
  - The potential risks to sustainable water management are:
    - extracting large volumes of low-quality water will impact on connected surface and groundwater systems,
    - with depressurisation changes are likely in adjacent aquifers,
    - reduction in surface water flows,
    - land subsidence over large areas,
    - the production and disposal of large volumes of treated and untreated waste water,
    - the potential to induce connection and cross contamination between aquifers,
    - Beneficial Uses can be affected,
    - Significant social impacts by disruption of current land-use practices, and
    - the long term nature of impacts that may occur and continue to have effect extending for a 100 years or more.
23. Issues of road access, piping, infrastructure at well sites, land acquisition, power lines and spacing between well sites are some of the many other concerns experienced in Queensland that have a negative impact on the social structure of a community.

## STATE GOVERNMENT CATCH UP & ENFORCEMENT

The State Government has as yet failed to develop functional and appropriate safeguards for Coal Seam Gas and if its record of enforcement of present legislation in regard to groundwater is any indication it fails miserably to ensure that Beneficial Uses rights are preserved.

- a. The Government must ensure that its authorities such as Southern Rural Water, Barwon Water, the Environment Protection Authority, the Corangamite Catchment Management Authority, and the Department of Sustainability and Environment enforce the policies and law as they presently stand, and
- b. fill the “black hole” that exists where there is little to no policy or legislation that specifically or adequately covers the exploration and extraction of Coal Seam Gas.

Unfortunately, one cannot be confident that many of the policies and management practices presently in place are enforced. Common excuses from State Government authorities being, “*That is not our responsibility,*” or “*We don’t have the funding to do this.*” Examples of this type of attitude by Government authorities are repeated over and over again in the Otway Water Books 1-14.

Government Policy has these things to say but in actuality there is scant implementation of the policies:

- **For Groundwaters of Victoria,**<sup>(6)</sup>
  - “*Protection of groundwater and aquifers is fundamental to the protection of environmental quality of surface waters.*”
  - The “*precautionary principle: where there are threats of serious or irreversible environmental damage, lack of scientific certainty should not be used as a reason for*

*postponing measures to prevent environmental degradation.”*

- The Principle of intergenerational equity, *“intergenerational equity: the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.”*
- **And for Waters of Victoria,** <sup>(7)</sup>
  - The Principle of integration of economic, social and environmental consideration including
    - *“Sound environmental practices and procedures should be adopted as a basis for ecological sustainable development for the benefit of all human beings and the environment.”*
    - *“This requires the effective integration of economic, social and environmental considerations in decision-making processes with the need to improve community well-being and the benefit of future generation.”*
    - The Principle of conservation of biological diversity and ecological integrity, *“The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision making.”*

Both of these State Environment Protection Policies have been designed...

- *“To guide the protection of beneficial uses...”*<sup>(7)</sup> and
- To include, *“Communities, businesses and protection agencies, including catchment management authorities, regional coastal boards, water authorities, municipal councils and relevant State government agencies, have responsibilities to plan or manage Victoria’s surface waters, and activities that impact on them, in an ecologically sustainable manner.”*<sup>(7)</sup>

In regard to utilisation and management of surface and ground waters in the Otway Range the applicability, implementation and enforcement of these policies and statements is ineffectual. They are treated with the same disdain as though they were “fluffy” motherhood type statements.

Otway Water Book 17 will deal with the inadequacy of the various State Government authorities to carry out their statutory responsibilities in regard to the management of our natural Otway Ranges water resources in a sustainable way. The Principles as mentioned above, and other law and responsibilities should be implemented without fear or favour. Coal Seam Gas exploration and extraction requires stringent and enforceable safeguards. Unfortunately, groundwater management cannot be used as an example of how it should be done, and as CSG is intricately entwined with groundwater and surface water, future prospects of a sustainable CSG industry where the rights of Beneficial Uses are preserved, seems most unlikely.

## **COS involvement in the Coal Seam Gas application for the Otway Ranges.**

Last May, 2010, the Colac Otway Shire posted this advertisement in the Colac Herald.

### **Notice of Exploration Licence**

#### **Application No.5277**

Council has received notice of an application by ECI International P/L and CFT CBM Holdings P/L for an Exploration Licence under the Mineral Resources Act.

The application is currently on public exhibition and interested parties are encouraged to view the application.

Objections to the application must be made in writing within 21 days of the notice and lodged with the Manager, Earth Resources Tenements, Department of Primary Industries, GPO Box 4440, Melbourne, Vic, 3001. Inquiries concerning the application can be directed to the Earth Resources Business Centre on (03) 9658 4454.

**Rob Small**

**Chief Executive Officer**

**[www.colacotway.vic.gov.au](http://www.colacotway.vic.gov.au)**

This advertisement gave no indication that the licence being sought was for the exploration of Coal Bed Methane. Considering the huge amount of adverse press that Coal Seam Gas has been attracting, it would have been appropriate to include the intent of this licence. As a consequence this notice drew little to no attention to the possible impacts that the issuing of a Coal Bed Methane exploration licence, could have upon the lives of the rates payers of the Colac Otway Shire.

The licence issuing process proceeded quietly and unobtrusively until December 2010 when the Department of Primary Industries issued the 5 year exploration licence (see appendix 2).

In an attempt to determine the Colac Otway Shire's involvement the CEO was asked on the 10 August 2011 what the process was and why the Colac Otway Shire was placing such an advertisement in the Colac Herald. The CEO could not answer the questions and had to take them on notice. Not having received a reply by 5 September 2011 the following explanation is the best that can be obtained to date. Of course, this explanation may require some modification at a later date if and when the process is fully explained.

*When a responsible and issuing authority is asked for a licence, applicants are told that they have to fulfil certain requirements. One of these requirements is to gain comment from referral authorities that have certain jurisdictional responsibilities that must be checked out first. In this instance the Colac Otway Shire would be one of these referral authorities and it is most likely Barwon Water, Southern Rural Water and the Corangamite Catchment Authority would also be referral agencies. Once the applicants clear the matter with these referral authorities they would then go back to the responsible authority, in this case the Department of Primary Industries, asking for the licence to be*

*issued. If there are no outstanding issues the licence is then issued.*

There is no doubt that the correct process would have been followed. However, the reason for placing advertisements and going through this process is to give the general public an opportunity to view, scrutinise and make comment on the issues taking place in their society. It is doubtful the intention of the process has been achieved in this case as few if anyone was aware of the nature of the licence being applied for.

Any statement asserting that the process has been followed: that is, drawing the issue to the public's attention and allowing ample time for viewing, discussion, think time and comment, is a nonsense.

## **CONCLUSION**

From which ever angle the issue of Coal Seam Gas in the Otway Ranges and District is approached, it would appear that a moratorium on CSG is the most responsible action to take until a cautious and responsible way to proceed has been seriously considered.

Peter Walsh, Water and Agricultural Minister, State Government Victoria on ABC Television 26-08-2011 7:30 Vic.

***“We have been at pains as, as a society to make sure we protect our water supply and the quality of our water supply.”***

***“If any proposal was going to put at risk Victoria's water supply or the quality of that water, uh, that's something that should not go ahead.”***

If like me, you have rushed to read the conclusion, I urge you to flip back and read pages 4 & 5.

## BIBLIOGRAPHY

1. Department of Primary Industries: A Guide to Coal Seam Methane for Landholders. As at 26-07-2011. Victorian State Government.
2. Federal Government Water Group (Australia), September 2010: Water Group Advice on EPBC Act Referrals QGC referral – 2008/4399, Santos-Petronas referral – 2008/4059 and comments on AP LNG referral – 2009/4974. Draft report based on information provided by the proponents to close of business 03/09/10.
3. Keith. K., Buader. J., Wheaton. J., 2003: Frequently Asked Questions, Coal Bed Methane (CBM) . Montana Bureau of Mines and Geology. Montana State University-Bozeman.
4. National Water Commission. December 2010: Position Statement Coal Seam Gas and Water. Australian Government.
5. U.S. House of Representatives. United States House of Representatives Committee on Energy and Commerce Minority Staff, April 2011: Chemicals Used in Hydraulic Fracturing.
6. Victorian State Government, 17 December 1997: State Environment Protection Policy, Groundwaters of Victoria . Special Gazette No. S 160.
7. Victorian State Government, 4 June 2003: State Environment Protection Policy, Waters of Victoria . Special Gazette No. S 107.

## **APPENDIX ONE**

### **Notice of Exploration Licence Application No.5277**

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Inquiries concerning the application can be directed to the Earth Resources Business Centre on (03) 9658 4454.

**Rob Small**  
**Chief Executive Officer**  
**[www.colacotway.vic.gov.au](http://www.colacotway.vic.gov.au)**

102888

Colac Herald 10 May 2010.

## APPENDIX TWO



TENEMENT AND REGISTRATION  
DETAILS  
EL5277

Created: Thu Jul 21 14:48:38 EST 2011

**MINING TITLE:** Exploration Licence 5277

**Old Title:**

**Application Received:** 31/03/2010

**Expiry:** 15/12/2015

**File Status:** CURRENT

**Inspectorate:** South West

**Owner (s):** \* ECI International Pty Ltd 352 Bay Rd Cheltenham  
VIC 3192  
CFT CBM Holdings Pty Ltd 352 Bay Rd  
Cheltenham VIC 3192

**General Correspondence:** C/- Elletson Mining Consultants Pty Ltd 4 Bayview  
St Bolwarra VIC 3305

**Reporting Correspondence:**

**Client Service Officer:** 5336 6806

**Minerals / Stone:** Coal Bed Methane

**Current Area:** 500.000 grats

**First Granted Area:** 500.000 grats

**Land Status:** Crown and private land and road and road reserves

**Bond:** 0

**Municipalities:** Colac Otway Shire

**Parishes:**

**Land Vic Regions:** South West

**Maps:** 7620 Otway 100  
7621 Colac 100

**Event History:**

Registration / Event Date	Folio No.	Comment
Grant of Licence 16/12/2010	<a href="#">F18314</a> 1904 kb	exp \$52,500 yr 1, \$75,000 yrs 2, 3 and 4 and \$90,000 yr 5

## **APPENDIX THREE**

Beneficial Uses as defined by the Victorian State Government.

Potable water.

Potable mineral water.

Irrigation.

Stock water.

Domestic water.

Industry.

Agriculture.

Buildings and structures.

Primary contact and recreation.

Ecosystem protection- both surface and subterranean.

## **APPENDIX FOUR**

The following pages 26-63, Appendix Four, is a copy of the “Loves Creek Total Catchment Water Balance Water.”

**Draft Two  
August  
2009**



Loves Creek

## Loves Creek Total Catchment Water Balance Plan

## Foreword

This book came about as a result of the realisation that the water resources in the Loves Creek Catchment were under threat of being extracted and sold for use outside the Catchment.

- It appeared that the local community was to have little say in this matter.
- This can be threatening to a community that relies heavily on the local water resources.
- Demand for extraction of water from the Otways for urban use was increasing and this demand did not appear to be based on sound management principles.
- Residents within the Catchment were becoming alarmed that the limited water resources were seen as infinite by people outside the Catchment.
- “Locals” felt that there was not enough water to service the present allocation demands within the Catchment let alone to service unfettered urban sprawl needs from outside the Catchment.
- This belief required supporting evidence otherwise it would not stand up to any form of scrutiny.

The simple answer seemed to be to draw up a total catchment water balance. That is compile data that shows exactly what water is available and how it is presently used and see if there is any left over for additional allocation. The success of carrying out such an ambitious plan depended on Catchment landholders’ participation and co-operation. The task has not been as simple as first thought but encouragingly this draft has been developed with an amazing amount of local community consultation and participation. It is hoped that those members of the community that have not had a chance to be involved, read this draft, and comment on its content. It is also hoped that this draft will inspire the statutory authorities to become involved.

Your comments can be sent to:

LAWROC  
C% Belinda Gardiner  
70 Campiglis Road  
Kawarren  
Vic 3249.

**LAWROC** stands for **L**and **A**nd **W**ater **R**esource **O**tway **C**atchment.

LAWROC is a Landcare Group affiliated with the Victorian Farmers Federation. LAWROC was formed not only to improve catchment health in the Otways BUT to ensure that no further degradation takes place as a result of over exploitation of water resources.



## Tony Burke

Tony Burke (Minister for Agriculture, Fisheries and Forestry – Federal) stated in the foreword of the book “Making A Difference,” that celebrates 20 years of Landcare Groups... *“Most importantly, the landcare model has shown that communities and individuals can achieve remarkable results when given the power and the opportunity to identify problems and implement their own solutions.”*

He also noted...

*“Our nation relies on our agricultural industries for food security and export revenue.”*

## Bobbie Brazil

In the same publication Bobbie Brazil (Chairman – Australian Landcare Council) stated... *“...the council relies heavily on its ‘on-ground’ volunteers to ensure a necessary reality check and knowledge base so that relevant ministers and other department officials can have confidence in its advice.”*

She said with regard to the consultation process...

*“...and ensure that consultation was explicit, open, meaningful and inclusive.”*

***The continued health of the environment and the agricultural prosperity of the Loves Creek catchment depend on these statements being nurtured and implemented.***

## State of the Environment Report.

Dr. McPhail<sup>6)</sup> tabled his State of the Environment Report in the Victorian parliament late in 2008. It is a most interesting and in many ways an alarming report. Following are some extracts taken from the Summary of this report.

- **Page 9, 10 & 25.** The State Government recognises that river health is an important indicator of overall environmental health of which man is an integral part. However, “To date the environment has been the loser,” and as a consequence so is man.
- **Page 9.** “The last assessment of river health in 2004 found that only one fifth of major rivers and tributaries in Victoria were in good or excellent condition.’
- “... of rivers and wetlands... 21 fish species, 11 frog species and 29 species of waterbirds are threatened, and only 14% of riverside vegetation along major rivers and streams in Victoria was found to be in good condition...”
- “...no statewide study of the extent of our wetlands has been undertaken since 1994”
- “...more than a third of our naturally occurring wetland area has already been lost and over 90% of the wetlands on private land has vanished.”
- **Page 10.** “In August 2008, groundwater levels in half of the most highly developed or potentially stressed groundwater areas were lowest on record.”
- **“Many rivers are not getting enough water to maintain their condition.”**
- “...the degraded state of many of our rivers shows that the way we manage our water resources has not secured the health of our inland waters.”
- “Adequate flows and environmental water reserves have not yet been agreed for many rivers and aquifers across Victoria.”

***“It is cheaper to protect the environment than it is to restore it, but it is even cheaper to degrade it.”***

(State of the Environment Report 2008)

## DEFINITIONS

“AKD” – Associated Kiln Dries.

“Catchment” – Loves Creek Catchment.

“CCMA” – Corangamite Catchment Authority

“COS” – Colac Otway Shire.

“DSE” – Department of Sustainability and Environment.

“Environmental Flow” - a flow that will maintain and where possible enhance species diversity and populations of aquatic life.

“Government” – Victorian State Government.

“Plan” – Loves Creek Total Catchment Water Balance Plan.

“S&D” – Stock and Domestic

“Spring” – an area smaller than 0.001 hectares (10 square metres) of permanent marsh, swamp, fen or peatland with water that is static or flowing, fresh or brackish.

“Stream” and “Creek” – synonyms for a permanent flowing body of water.

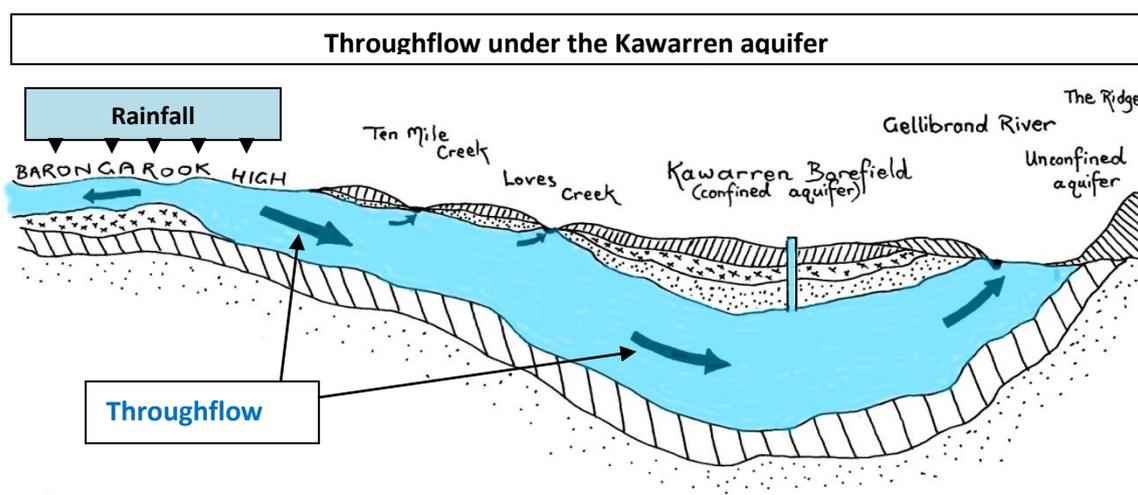
“Throughflow” – rainfall that enters the aquifer and then flows through the aquifer under ground (see diagram below).

“Trees” – all vegetation taller than 5 metres (unless defined otherwise in the text).

“Sustainability” - Surface and groundwater resource utilisation that protects, social, economic and environmental values.

“VFF” –Victorian Farmers Federation.

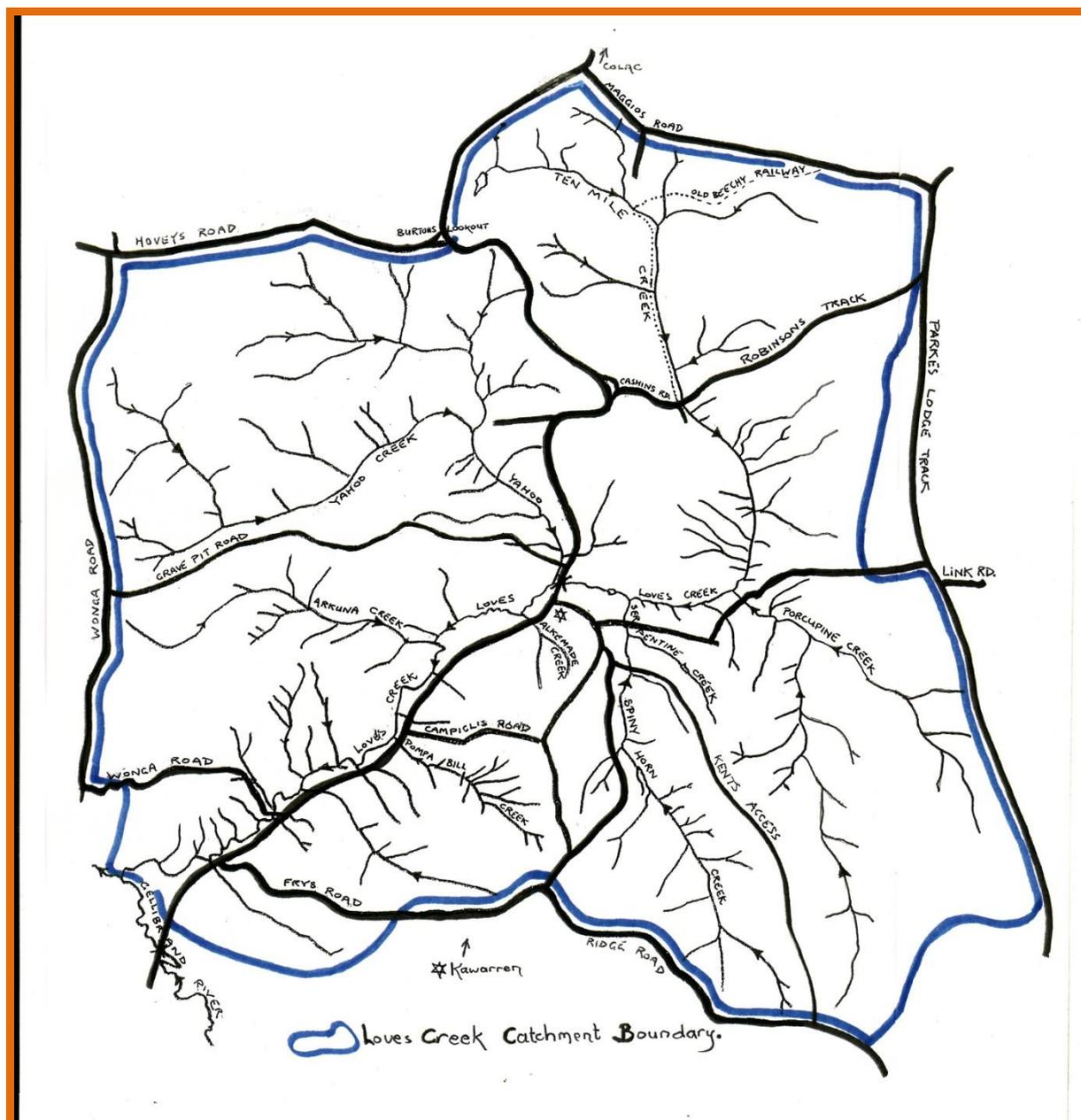
“Wetland” – an area bigger than 0.001 hectares (10 square metres) of permanent marsh, swamp, fen or peatland with water that is static or flowing, fresh or brackish.



## LOVES CREEK TOTAL CATCHMENT WATER BALANCE PLAN

Streams and associated wetlands and springs under this Plan include the TEN MILE, YAHOO, PORCUPINE, SERPENTINE, SPINY HORN, ARKUNA, ALKEMADE, JUKES, POMPA BILL and LOVES creeks and their many tributaries.

### Loves Creek Catchment Map



The Loves Creek catchment is approximately 83 km<sup>2</sup> and has numerous water features. This catchment forms an important part of the Gellibrand River catchment and is within the boundaries of the Gellibrand Groundwater Management Area.

## BACKGROUND

In 1999 the Permissible Annual Volume of groundwater extraction from within the Gellibrand Groundwater Management Area (GGMA) was recommended to be set at zero (Woodward-Clyde 1999<sup>(9)</sup>). The intent of the recommendation was there should be no groundwater extraction at any time from any aquifer within the Gellibrand GMA including the Eastern View Formation (made up of the Mepunga, Dilwyn and Pebble Point Formations). The report containing this recommendation also stated...

*“An area of 12 km<sup>2</sup> of outcropping aquifer (Barongarook High) material was interpreted as the recharge zone for the Kawarren sub-basin with a groundwater throughflow calculated at 1900 ML/year. The aquifer system contributes baseflow to major streams in the Gellibrand GMA namely the Ten Mile, Porcupine, Yahoo and Loves Creek.”*

Seven years later in 2006 the Victorian State Government Gazetted that the Permissible Consumptive Volume (used to be called the Permissible Annual Volume) from all aquifers within the Gellibrand GMA be set at ZERO.

In July 2008, Water Minister Tim Holding, Gazetted that the PCV for the Gellibrand GMA be reset at 625 ML for a short period allowing Barwon Water to conduct a test pump with the aim of determining the feasibility of extracting 16 000 ML/year for Geelong urban use. Sixteen thousand million litres (16 000 ML) is 8.42 times the calculated throughflow.

Woodward-Clyde<sup>(9)</sup> (1999) calculated that pumping only 3 700 ML/year from the Kawarren borefield could potentially reduce the summer flow in the Gellibrand River by 35%. These calculations indicate that extracting 16 000 ML/year would dry the Gellibrand River up.

### **An Important Study Done in the Loves Creek Catchment**

There have been numerous studies done on the Gellibrand River and it has been widely reported for decades that the environmental importance of this river is significant. What is not well known is that Zampatti et al.<sup>(10)(11)</sup> carried out a study in the Loves Creek catchment and found this system of streams and creek was as significant as the Gellibrand River in many respects. When the Loves Creek Catchment was investigated the distribution and composition of fish assemblages was found to be significant and, at some sites, unique in the Otways. The co-existence of certain species had not been recorded in the Otways at any other site. The size of the blackfish population suggested that Loves Creek should be given the same recognition and status, with regard to blackfish, as the Gellibrand River. The likelihood that small tributaries of Loves Creek act as breeding grounds, nursery streams, for a diverse assemblage of biota that in turn replenish and re-vitalise the larger creeks and rivers, is an area of study yet to be conducted in the Loves Creek catchment.

## Why Have A Plan?

A quality total catchment water balance has never been done on the Loves Creek Catchment. This is critical as a water balance encompasses all of the factors influencing the water regime and goes some way to determining the availability of any free resource. These factors would include rainfall, runoff, stream flow, groundwater recharge, groundwater extraction, loss of groundwater to other catchments, stock, domestic, urban and licensed use of water, evapotranspiration (“*water lost through the combined effects of evaporation from the ground surface and transpiration from the vegetation*” – Evans<sup>(1)</sup>), farm dams, effluent from homes and agriculture, climate change and any other factor influencing the water resource within the Catchment. It is extremely difficult to sustainably manage a resource if the contributing factors influencing the resource are only partly understood. Many of these factors are canvassed when compiling a total catchment water balance. To compile a total catchment water balance requires a start being made. This Plan is that start.

In 2007, Evans<sup>(1)</sup> in a technical report “The Impact of Groundwater Use on Australia’s Rivers” refers to total catchment water balance. He points out that “...*frequently the water balance is almost never ‘closed’* (i.e. all things considered) *and major assumptions are made about key components of it.*” In most cases the complete or ‘closed’ data is not collected. Evans calls for “...*quality total catchment water balances.*” As previously stated this Plan does not pretend to be such a quality study but is a start which is far and beyond any other study attempted in this Catchment.

In any form of management critical decisions and successful outcomes can only be made if the managers have an adequate data base on which to make informed decisions. In regard to water allocation and use, the development and compiling of a quality total catchment water balance is crucial.

## AIM of the PLAN

This plan aims at maintaining a sustainable use of the groundwater and surface water resources of the Loves Creek Catchment.



A healthy Loves Creek

## SUSTAINABILITY

The definition of sustainability used to in this document is as follows...

*"Surface and groundwater resource utilisation that protects, social, economic and environmental values."*

The principles on which this definition has been based can be found in the Statement of Obligations set down for Barwon Water, by the State Government in 2007.

In this Statement of Obligations<sup>(8)</sup> "Sustainable Management Principles" include the following...

- ❑ The need to ensure that water resources are conserved and properly managed for sustainable use and for the benefit of present and future generations, and
- ❑ The need to encourage and facilitate community involvement in the making and implementation of arrangements relating to the use, conservation and management of water resources; and
- ❑ The need to integrate both long-term and short-term economic, environmental, social and equitable considerations; and

- ❑ The need for the conservation of biological diversity and ecological integrity to be a fundamental consideration; and
- ❑ If there are threats of serious or irreversible environmental damage, lack of full scientific certainty as to measures to address the threat should not be used as a reason for postponing such measures.

This Total Catchment Water Balance Plan has been developed with State Government policy foremost in the minds of the stakeholders of the Loves Creek Catchment. These policies include...

- the Government's recognition that the environment has often been overlooked and not given adequate consideration,
- preservation of wetlands,
- maintenance of healthy streams,
- improving of degraded waterways,
- protection of groundwater from over exploitation,
- precautionary principles where there are threats of serious or irreversible environmental damage,
- intergenerational equity where the present generation ensures that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations,
- that obligation that groundwater managers must ensure that their activities do not pose an environmental risk to surface water beneficial uses (Vic. Gov. Gazette S107 June 2003),
- the obligation that catchment activities should not pose an environmental risk to groundwater beneficial uses (Vic. Gov. Gazette S107 June 2003),
- the management of water to be based on an understanding that a healthy economic society is dependent on a healthy environment,
- the water sector will be capable, innovative and accountable to the Victorian community,
- the requirement that surface and groundwater resources are not over allocated,
- the requirement for review and adjustment in the event any over allocation of resources.

## **BENEFICIAL USES**

The following list of Beneficial Uses has been determined by the State Government.

- Potable Water
- Potable Mineral Water
- Irrigation
- Stock Water
- Domestic Water
- Industry
- Agriculture
- Buildings and Structures
- Primary Contact Recreation
- Ecosystem Protection – both surface and subterranean

## ENVIRONMENTAL FLOWS

The definition of an environmental flow used in this document is,

*“... a flow that will maintain and where possible enhance species diversity and populations of aquatic life.”*

## REGULATED/UNREGULATED STREAMS

In the Loves Creek catchment (see map, page 5) all streams are unregulated (no dams or reservoirs).

## REVIEW

The proposed Plan will be open to review at any time. Unlike other plans there is no set period before a review can be done. If a circumstance arises necessitating a review then it will be done. Too often licences given for a set period do not make adequate provision for review in the eventuality that serious issues arise.

## TOTAL CATCHMENT WATER BALANCE

The following breakdown of a total catchment water balance has been adopted from Evans.<sup>(6)</sup>

### Water stored in the catchment

- Farm dams off stream
- Dams on-stream
- Aquifer(s)
- Saturated soils
- Soils in the unsaturated zone
- Stream channels

### Inflow into the catchment

- Rainfall
- Returns from consumptive users (homes/agriculture etc.)

### Internal Interchange

- Rainfall to surface water
- Surface water to soil – unsaturated zone
- Rainfall to soil
- Extraction for consumptive use-household/agricultural
- Return from consumptive use

### Outflow

- Evapotranspiration from soils and aquifers
- Evapotranspiration from surface waters
- Transpiration from vegetation
- Consumptive use within the catchment
- Consumptive use outside the catchment
- Surface flow out of the catchment
- Aquifer flow out of the catchment

## PREPARATION OF THE PLAN

Partnership and joint action are pivotal in the effective implementation of this Plan. A unique feature of attempting to actively involve all landholders will hopefully gain local community engagement and ownership. This Plan has been developed through local community input.

Advice and help from Government Authorities such as Southern Rural Water, the Corangamite Catchment Authority, the Department of Sustainability and Environment, Parks Victoria, Victorian Farmers Federation, the Colac Otway Shire Council and commercial timber companies was sought.

In August 2008 over 200 questionnaires were delivered in the catchment. Although the return rate was disappointing, follow up personal approaches were extremely successful. 98.72% of landholders wanted to be involved.

The landholders of this Catchment have a wide ranging diversity of occupations and abilities. The commercial enterprises are varied and vitally important to the social structure of the community.

At this early stage there are still many more people to visit. This should be done in due course and the success of this will be reflected in Draft Two of the Plan. The development of this Plan is a dynamic process.

## Invitation to Responsible Authorities to Participate

In the first week of February 2009 invitations to participate in the development of this Plan were sent to the managers of the following organisations. Any assistance from these organisations and individuals in the development of this plan would be gratefully acknowledged. However, the response rate and assistance to date has been extremely limited.

- |   |  |
|---|--|
| • <i>No response</i>                        | Southern Rural Water                       |
| • <i>Declined Offer</i>                     | Corangamite Catchment Management Authority |
| • <i>Declined Offer</i>                     | Parks Victoria                             |
| • <i>Prepared to make comment on drafts</i> | Colac Otway Shire                          |
| • <i>No Response</i>                        | Department of Sustainability & Environment |

## Sense of Direction

Resident and absentee landholders approached so far have a strong sense for current and future wellbeing of the natural water resources. Protection and enhancement of the Loves Creek Catchment water resources are viewed as critical to the wellbeing of this Catchment and ecosystems downstream. The threat of over exploitation of the water resources in this Catchment balances on a knife edge and will remain, given climate change and other demands from within and outside the Catchment. The application of robust logic for determining any further water resource development is paramount.

## Well Being

The water resources of the Catchment are equally important to the future wellbeing of the natural environment as well as the human population. All Beneficial Uses (see page 9) must be taken into consideration when a change in allocation of water resources is being contemplated.

## Rights Identified

The Plan identifies wetlands, springs and streams that must be protected or enhanced, as per Government policy. The Plan identifies landholders rights under the water Act 1989 that must be maintained.

The rights of Beneficial Uses of water resources that flow out of the Loves Creek Catchment such as ecosystems downstream should also be taken into consideration when developing a catchment plan. Visitors to the Catchment such as fishermen, photographers, walkers, bike riders, campers etc. visiting the Catchment should also be considered. Maintaining the integrity and if at all possible, improving the environment for future generations should be of the highest priority.

## Future Directions

This Plan makes recommends in line with state and national water strategies, policies and commitment.

## Identifying Threats

An attempt has been made to identify those circumstances that pose a threat to the delicate water balance within the Catchment and how these could be dealt with.



Acid water with high levels of Aluminium & iron.



Acid effects.

**Threats to avoid that are being experienced along Boundary Creek (an adjoining catchment).**



Fire after being dried out.



Concrete cancer.

Some of the effects being experienced along Boundary Creek from over exploitation of groundwater at the Barwon Downs borefield.



Toxic levels of heavy metals.



Over exploitation of water resources can have devastating effects – creeks can dry up, Actual Acid Sulfate Soils can be created, land can subside and in extreme cases deserts can be formed.

Influences from groundwater extraction can be noted in some cases within hours while in others the effects may not become apparent until decades after the pumping has ceased (Evans<sup>(1)</sup>). There are a multitude of scenarios in between these two extremes.

## DATA COLLECTED

The data collected to this stage is a reflection of only 78 residential properties. There is still much to be collected as many residents have still to be interviewed.

**Ten Mile Creek Catchment – average daily summer flow pre drought 1.2 ML**

### Name of participants

- Greg Bishop
- Brian Moore
- Mary & Robert Maxwell
- Ray Moorfoot
- David Cracknell
- Phil Thompson
- Marty Whytcross
- Jane McEwan
- James Chapman
- Sally & Hugh Clarke
- Des Alford
- Franz & Elizabeth Fliss
- Terry Woodcroft
- Michael & Christopher Armytage

### Summary of Data Collected so far

- Area 576.7 hectare
- Area under trees 170.09 hectare
- Area under other vegetation 406.61 hectare
- Age Range of trees 1-100 years
- Giving the conservative water requirement for trees per hectare at 3 ML/year this would equate to 510.27 ML
- Number of dams 35
- Use of the dams 35 S&D 35 fire protection 1 irrigation (licensed)
- Given an average capacity of 0.3 ML per dam this would equate to 10.5 ML
- Licensed Surface water use 58.4 ML irrigation. ZERO ML Stock and Domestic
- Under Section 8 of the Water Act 1989 –unregistered S&D entitlement 28.8 ML
- Licensed bore use ZERO ML
- Registered S&D bore use ZERO ML
- Domestic Tank Capacity 0.3178 ML
- Homes on Town Water – ZERO
- Total Homes Surveyed 15
- Homes reliant on rainfall, springs, streams 15
- Homes reliant on dams, tanks, springs, streams and or CFA for fire protection 15
- Ephemeral Springs 19
- Permanent Springs 24
- Wetlands 5.2 hectare

**Licensed and unregistered Stock and Domestic entitlements, alone, committed from surface waters TOTALS 28.8 ML/year.**

## Yahoo Creek Catchment – average daily summer flow pre drought **0.8 ML**

### Name of participants

- Nancy & Chris Day
- David & Janet Hopkins
- Alan Porteous (Kawarren)
- Nelson & Lorraine Horne
- Data collected from landholder – name withheld.

### Summary of Data Collected so far

- Area 180.9 hectare
- Area under trees 108.9 hectare
- Area under other vegetation 72 hectare
- Age Range of trees 3-60 years
- Giving the conservative water requirement for trees per hectare at 3 ML this would equate to 326.7 ML/year
- Number of dams 12
- Use of the dams 12 S&D 12 fire protection ZERO irrigation (licensed)
- Given an average capacity of **0.3 ML** per dam this would equate to 3.6 ML
- Licensed Surface water use ZERO ML irrigation. ZERO ML Stock and Domestic
- Under Section 8 of the Water Act 1989 –unregistered S&D entitlement 8.8 ML
- Licensed bore use ZERO ML
- Registered S&D bore use ZERO ML
- Domestic Tank Capacity 0.23218 ML
- Homes on Town Water – ZERO
- Total Homes Surveyed 5
- Homes reliant on rainfall, springs, streams 5
- Homes reliant on dams, tanks, springs, streams and or CFA for fire protection 5
- Ephemeral Springs - Many
- Permanent Springs - Not Known
- Wetlands 19 hectares

**Licensed and unregistered Stock and Domestic entitlements, alone, committed from surface waters TOTALS **8.8 ML/year.****

## Porcupine Creek Catchment – average daily summer flow pre drought **0.2 ML**

### Name of participants

- Peter McDonald
- Franz & Elizabeth Fliss

### Summary of Data Collected so far

- Area 179 hectare
- Area under trees 10 hectare
- Area under other vegetation 169 hectare
- Age Range of trees 5-70 years
- Giving the conservative water requirement for trees per hectare at 3 ML this would equate to 30 ML/year
- Number of dams 9
- Use of the dams 9 S&D 9 fire protection ZERO irrigation (licensed)
- Given an average capacity of **0.3 ML** per dam this would equate to 2.7 ML
- Licensed Surface water use ZERO ML irrigation. 4 ML Stock and Domestic
- Under Section 8 of the Water Act 1989 –unregistered S&D entitlement 2.2 ML
- Licensed bore use ZERO ML
- Registered S&D bore use ZERO ML
- Domestic Tank Capacity 0.0677 ML
- Homes on Town Water – ZERO
- Total Homes Surveyed 3
- Homes reliant on rainfall, springs, streams 3
- Homes reliant on dams, tanks, springs, streams and or CFA for fire protection 3
- Ephemeral Springs 1
- Permanent Springs 0
- Wetlands 6-7 hectare

**Licensed and unregistered Stock and Domestic entitlements, alone, committed from surface waters TOTALS **6.2 ML/year.****

## Serpentine/Spiny Horn Creeks Catchment – average daily summer flow pre drought **not gauged**

### Name of participants

- Neville & Chris Towers
- Jill & Chris Varney
- Richard Dawes
- Carl Bolton
- Chris Scown
- Penny McGluggin

### Summary of Data Collected so far

- Area 296 hectare
- Area under trees 268 hectare
- Area under other vegetation 28 hectare
- Age Range of trees 10-100 years
- Giving the conservative water requirement for trees per hectare at 3 ML this would equate to 804 ML/year
- Number of dams 22
- Use of the dams 22 S&D and 22 fire protection
- Given an average capacity of **0.3 ML** per dam this would equate to 6.6 ML
- Licensed Surface water use 25 ML irrigation ZERO ML Stock and Domestic
- Under Section 8 of the Water Act 1989 –unregistered S&D entitlement 6.6 ML
- Licensed bore use 2.2 ML
- Registered S&D bore use ZERO ML
- Domestic Tank Capacity 0.5033 ML
- Homes on Town Water – ZERO
- Total Homes Surveyed 6
- Homes reliant on rainfall, springs, streams 6
- Homes reliant on dams, tanks, springs, streams and or CFA for fire protection 6
- Ephemeral Springs - Numerous
- Permanent Springs - Numerous
- Wetlands 33.5 hectares

**Licensed and unregistered Stock and Domestic entitlements, alone, committed from surface waters TOTALS **8.8 ML/year.****

# Arkuna Creek Catchment – average daily summer flow pre drought **not gauged** – never been known to dry up

## Name of participants

- Carol & Mick Maxwell

## Summary of Data Collected so far

- Under Section 8 of the Water Act 1989 –unregistered S&D entitlement 2.2 ML
- Wetlands 1 Hectare

**Licensed and unregistered Stock and Domestic entitlements, alone, committed from surface waters TOTALS 2.2 ML/year.**

## Alkemade Creek Catchment – average daily summer flow pre drought **not gauged** – never been known to dry up

### Name of participants

- Lee Kennedy
- Rick Tucker
- Wendy Howard
- Peter Brown
- Pam Winn
- Elizabeth & Werner Hourticolon

### Summary of Data Collected so far

- Area 17.6 hectare
- Area under trees 5.5 hectare
- Area under other vegetation 12.1 hectare
- Age Range of trees 2-60 years
- Giving the conservative water requirement of trees per hectare at 3 ML a year this would equate to 16.5 ML/year
- Number of dams 6
- Use of the dams 6 S&D                      6 fire protection              ZERO irrigation (licensed)
- Given an average capacity of **0.3 ML** per dam this would equate to 1.8 ML
- Licensed Surface water use ZERO ML irrigation      ZERO ML Stock and Domestic
- Under Section 8 of the Water Act 1989 –unregistered S&D entitlement 2.2 ML
- Licensed bore use ZERO ML
- Registered S&D bore use ZERO ML
- Domestic Tank Capacity 0.26038 ML
- Homes on Town Water – ZERO
- Total Homes Surveyed 6
- Homes reliant on rainfall, springs, streams 6
- Homes reliant on dams, tanks, springs, streams and or CFA for fire protection 6
- Ephemeral Springs 2
- Permanent Springs 2
- Wetlands 1

**Licensed and unregistered Stock and Domestic entitlements, alone, committed from surface waters TOTALS **2.2 ML/year**.**

## Pompa Bill/Jukes Creeks Catchments – average daily summer flow pre drought **0.09 ML**

### Name of participants

- Mal & Kay Gardiner
- Stuart & Belinda Gardiner
- Shane Flanagan
- David & Tricia Jukes

### Summary of Data Collected so far

- Area 140.8 hectare
- Area under trees 31.65 hectare
- Area under other vegetation 109.15 hectare
- Age Range of trees 1-70 years
- Giving the conservative water requirement for trees per hectare at 3 ML this would equate to 94.95 ML/year
- Number of dams 18
- Use of the dams 18 S&D and 18 fire protection
- Given an average capacity of **0.3 ML** per dam this would equate to 5.4 ML
- Licensed Surface water use ZERO ML irrigation ZERO ML Stock and Domestic
- Under Section 8 of the Water Act 1989 –unregistered S&D entitlement 6.6 ML Pompa Bill Creek and 2.2 ML Jukes Creek
- Licensed bore use ZERO ML
- Registered S&D bore use ZERO ML
- Domestic Tank Capacity 0.278334 ML
- Stock tank capacity 0.265 ML
- Homes on Town Water – ZERO
- Total Homes Surveyed 4
- Homes reliant on rainfall, springs, streams 4
- Homes reliant on dams, tanks, springs, streams and or CFA for fire protection 4
- Ephemeral Springs 10
- Permanent Springs – Numerous
- Wetlands 5 hectares

**Licensed and unregistered Stock and Domestic entitlements, alone, committed from surface waters TOTALS **8.8 ML/year**.**

## Loves Creek – average daily summer flow pre drought **2.2 ML**

### Name of participants

- Gordon & Dianne Hynes
- T & L Lloyd
- Paul Fitzgerald
- Terry Cooper
- James Johnson
- Nicole & Greg Parker
- Michael & Carol Maxwell
- John & Jane Mollard
- Bill & Rosaria Lambert
- Russell Peterson
- Ian Jordan
- Jean Harrison
- Dijanne Cevaal
- Peter & Heather Smith
- Sheila McLennan
- Robert Tootell
- Christine McDonnell
- John & Mireille Golding
- Graeme & Carol McDonnell
- Irene & Ed Bridgeman
- Frank & Michelle Dimasi
- Glenys McRae
- Graeme & Stephanie Sutherland
- Anna-Elizabeth & Vicki Anne Parij-Smith
- Daniel Smith
- Ken Perkins
- Liz Hamilton
- Andrew & Brenda Grimshaw
- Gu & Lena Kiesel
- Helen Clarke
- Leo Grillinzoni
- Tim & Linda Phillips
- Annette Molloy
- Nick Theophilou
- John Moccan
- Rita & Mark Britton
- Tristan Calvin
- Dean Mahoney
- Jacinta Hayes
- Ian Cartwright
- Mary & Rob Maxwell

### Summary of Data Collected so far

- Area 689.4 hectare
- Area under trees 149.14 hectare
- Area under other vegetation 540.26 hectare
- Age Range of trees 1-100 years
- Giving the conservative water requirement for trees per hectare at 3 ML this would equate to 447.42 ML/year
- Number of dams 71
- Use of the dams 71 S&D, 71 fire protection, 2 irrigation (licensed)
- Given an average capacity of 0.3 ML per dam this would equate to 21.3 ML
- Licensed Surface water use 204 ML irrigation. 26.2 ML Stock and Domestic
- Under Section 8 of the Water Act 1989 –unregistered S&D entitlement 24.2 ML
- Licensed bore use ZERO ML
- Registered S&D bore use ZERO ML
- Domestic Tank Capacity 2.005 ML
- Homes on Town Water – ZERO
- Total Homes Surveyed 41
- Homes reliant on rainfall, springs, streams 41
- Homes reliant on dams, tanks, springs, streams and or CFA for fire protection 41
- Ephemeral Springs 20 plus
- Permanent Springs 21
- Wetlands – approximately 5 hectares

**Licensed and unregistered Stock and Domestic entitlements, alone, committed from surface waters TOTALS 50.4 ML/year.**

## Summary of the Data Collected - Loves Creek Catchment

Total Number of participants asked to be involved was 96. One resident declined to be interviewed. The timber companies, after verbal discussion, did not respond to a written invitation. The five statutory authorities declined to have any input. The Colac Otway Shire volunteered to view draft Plans.

Loves Creek Catchment has a total area of approximately 8 300 hectares including Timber Company Private Forest Estate and Crown Land Forest. Included in these areas are Forest and National Parks, Picnic Reserves, Natural Feature Reserves and a Reference Area. Reference Areas are areas reserved as specific representative parts of Victoria that are to have no human intervention take place within their boundaries.

### Summary of Loves Creek Catchment Data Collected so far

- The Total area of the Loves Creek Catchment is approximately 8 300 hectares
- Approximate area under trees 7 215 hectares
  - 4 615 Crown Land
  - 1 620 private forest
  - 310 pine plantation
  - 670 blue gum plantation (this includes pine plantation destined to become blue gums).
- Area under other vegetation 1 085 hectares
- Given a conservative figure for the water requirement for trees per hectare at 3 ML this would equate to 21 645 ML/year
- Given a conservative figure for the water requirement for other vegetation per hectare at 1 ML this would equate to 1 085 ML/year
- Number of dams 173
- Use of the dams were for S&D, fire protection and irrigation (licensed)
- Given an average capacity of 0.3 ML per dam this would equate to 51.9 ML
- Licensed Surface water use 287.5 ML irrigation, 30.2 ML Stock and Domestic
- Under Section 8 of the Water Act 1989 –unregistered S&D entitlement 86 ML
- Licensed bore One
- Registered S&D bore use Not known (data not supplied)
- Domestic Tank Capacity 3.664694 ML
- Homes on Town Water – Zero
- Homes reliant on rainfall, springs, streams – all that were surveyed
- Homes reliant on dams, tanks, springs, streams and or CFA for fire protection – all homes surveyed
- Ephemeral Springs - Numerous
- Permanent Springs - Numerous
- Wetlands 76.2 hectares on landholders other than Crown/Forestry land.
- Wetlands on Crown and Forestry land an additional approximate 50 hectares.
- Various studies have calculated that between 1500-3000 ML of rain that falls soaks into the ground recharging the deep water aquifer and is discharged into the Gellibrand River

Licensed and unregistered Stock and Domestic entitlements, alone, committed from surface waters TOTALS 116.2 ML/year.

The total house tanks, dams, trees, other vegetation, irrigation and stock and domestic has a minimum capacity to use 23 189 ML/year (groundwater recharge not included).

## DISCUSSION

With the limited resources available to LAWROC it would seem impossible to gather all of the data to conduct a comprehensive Total Water Balance for the Loves Creek Catchment (see page 10). The work completed gathering data to this point has been enormous and the amount to be gathered seems insurmountable given the lack of co-operation from statutory authorities (see page 11). Combined with this reluctance to participate by authorities there also appears to exist significant hindrance and distortion of evidence. Processes such as this can be very discouraging. However, the data so far compiled indicates that there is a desperate need to continue this work.

It seems almost beyond belief that Southern Rural Water, the Corangamite Catchment Management Authority, Parks Victoria and the Department of Sustainability and Environment have declined to be involved in the preparation of this Plan. At least the Colac Otway Shire has indicated an officer would be interested in looking at drafts of the Plan. Considering that this Plan is a genuine effort by the Loves Creek Catchment community to attempt something never before done in the Otways, and considering that drawing up such a Plan is now regarded as best catchment management practice,<sup>(1)</sup> it is most baffling that the statutory authorities given the responsibilities to manage the State's Otway water resources are abdicating any involvement. The question then has to be asked, what are the roles and responsibilities of a Catchment Management Authority and other State Government authorities, if one of them is not catchment management.

In 1990 Hebblethwaite and James<sup>(2)</sup> calculated that the Loves Creek Catchment had an average rainfall of 900 mm. Using this figure and the summary figures above, the following calculations can be made.

Rainfall	Potential Volumes Used	Used for
900 mm	2250 ML	Groundwater recharge
	3.7 ML	House Tanks
	51.4 ML	Dams
	21 645 ML	Trees (plantation & Natural Bush)
	1085 ML	Vegetation
	287.5 ML	Irrigation
	116.3 ML	Stock & Domestic
<b>Total Rainfall 67 500 ML</b>	<b>Minimum Total Used 25 439.3 ML</b>	42 060.7 ML Maximum loss from the catchment.

It has already been stated that this Plan is in its development stage but as far as it has gone, the Plan presents an interesting snapshot. In most cases calculations have been extremely conservative. For example the dam and house tank usage would be more due to use and replenishment during rainfall episodes. The amount of rain captured and used would be much more. Many residents are still to be interviewed. Tree and vegetation use of the water resource is also extremely conservative. Studies have shown that growing blue gum forests consume much more than 3 ML/hectare/year as used in the calculations in this Plan. The

overflow from the Catchment would take place mostly through the winter months during major rainfall episodes. However, the amount of rainfall utilised is significant and demonstrates the reliance placed on water resources.

At this stage there would appear to be two ways that water is lost to other catchment areas. The most obvious being via stream flow down Loves Creek into the Gellibrand River. This over flow of surface water from the Loves Creek Catchment into the Gellibrand River system performs a vital role sustaining the water dependent ecosystems and communities within the Gellibrand River; the Gellibrand estuary; stock & domestic; irrigation and urban water requirements downstream. These Beneficial Uses rights would be placed under duress if further extraction of groundwater or surface water resources from the Loves Creek Catchment were granted.

In 1993 Khouri and Duncan<sup>(4)</sup> completed a report studying the sustainability and security of water resources for western Victorian towns supplied by water from the Gellibrand Catchment. They stated that in the event of a drought many western Victorian towns relying on the Gellibrand River as a water resource, would run dry, *if* the most basic summer environmental flow was applied to the Gellibrand River. Towns such as Camperdown, Simpson, Lismore, Derrinallum and Cobden to name a few.

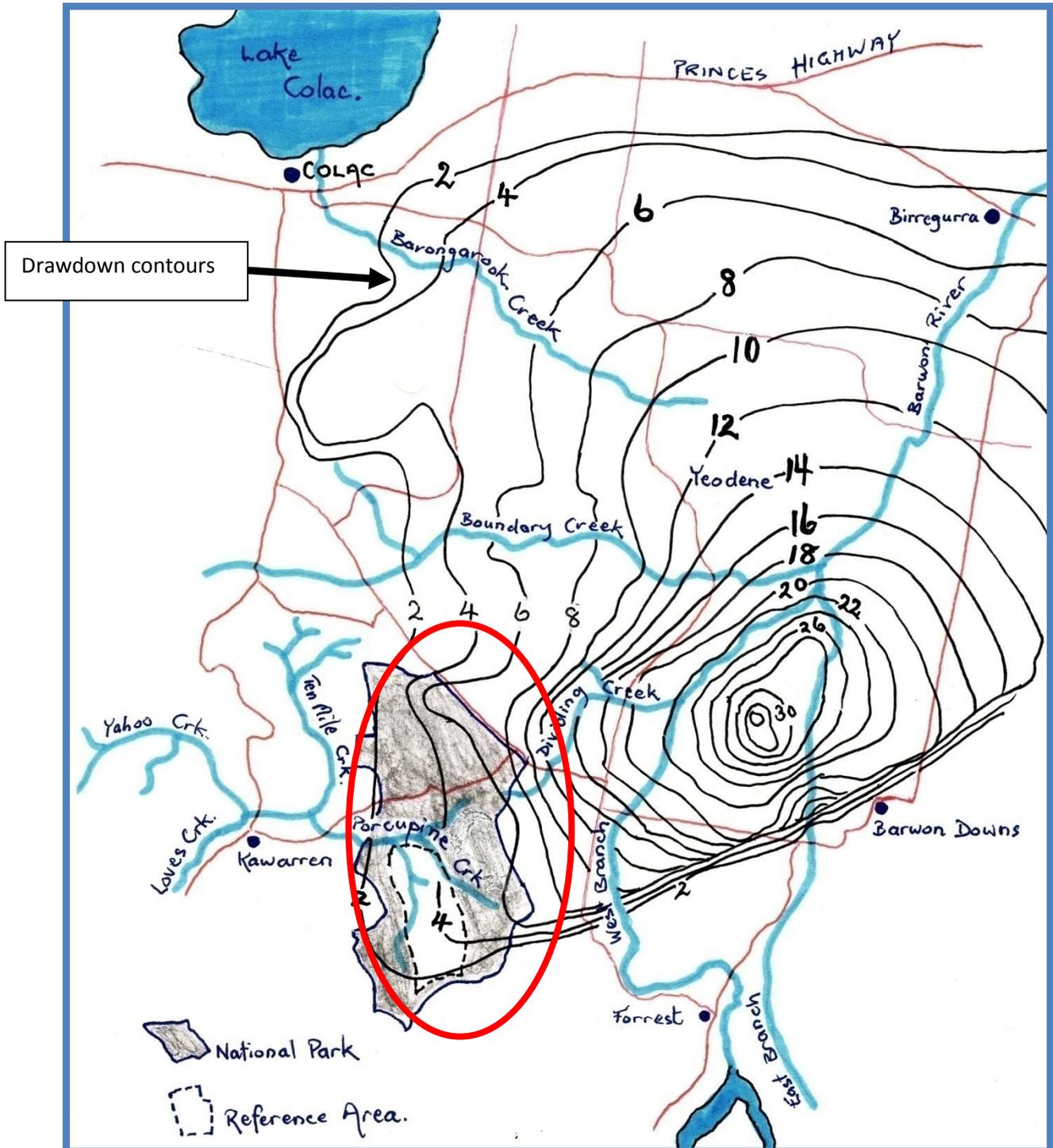
The most basic summer environmental flow has not been allocated to the Gellibrand River. There isn't enough surface water flow to make such an allocation without placing urban water supplies under threat. Considering the Khouri report was completed back in 1993 when there was an abundance of rainfall compared to the last few years, the allocation of an environmental flow would seem to be even more remote in 2009. There wasn't any water available for an environmental flow component in 1993 and there is most definitely none available today. The only conclusion that can be drawn from this is that the Gellibrand River system, including the Loves Creek Catchment, is already fully allocated. Incidentally there has been no allocation of an environmental flow for any creek within the Loves Creek Catchment.

All of the streams in the Loves Creek Catchment that have continued to flow throughout this worst drought on record are sourced from groundwater during non rainfall periods. This groundwater sustains the summer surface water flows. These groundwater resources are by default, already fully allocated for Beneficial Use before it reaches the surface. In reality the summer surface waters and the groundwater discharge are one and the same resource. To calculate surface water as one resource and groundwater as another would be counting the same amount of water twice. This Plan does not do that.

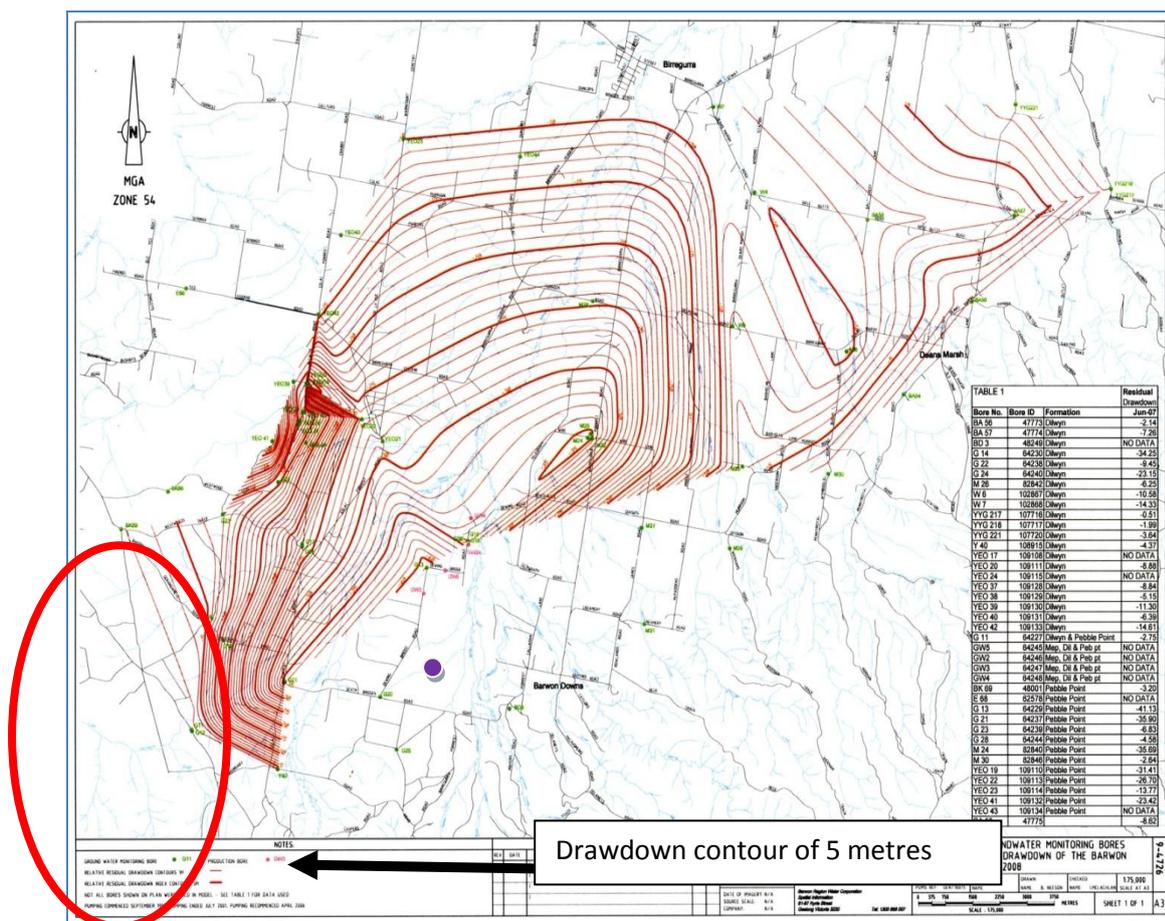
The other less obvious loss of water from the Loves Creek Catchment is the depletion of groundwater resource via drawdown effect from adjoining borefields. There would appear to be little influence from the Wannon Water borefield at Carlisle River. However, there does appear to be a convincing argument that there is a drawdown influence from the Loves Creek catchment due to the Barwon Water borefield at Barwon Downs. The diagram below (Map 1) is many years old but clearly demonstrates that there is a significant drawdown far into the Loves Creek Catchment. Given that there has been extensive extraction of

groundwater from the Barwon Downs borefield since 2002 it would be reasonable to suggest that the current effects would be considerably more.

When requested in 2008, Barwon Water would not provide any other documentation than the data provided in the 2007-08 annual report (see Map 2). Barwon Water was asked to provide drawdown contour lines as a result of groundwater extraction at the Barwon Downs borefield, out to the point of zero influence. As can be seen in Map 2 huge sections of data are missing including the area of influence into the Loves Creek Catchment.



Map 1. Data provided by Barwon Water 2002. (The area circled in red is similar to the area circled in the next map)



(The red ovals in the two maps cover approximately the same area.)

As with much of the data provided by Barwon Water in its annual reports to Southern Rural Water across the Barwon Downs borefield, this map is difficult to read. The drawdown data is provided in Map 2. Data provided in the 2007-08 Barwon Water annual report to Southern Rural Water.

groundwater extraction at Barwon Downs. The purple spot indicates the borefield where the drawdown influence is most pronounced. At this point drawdown data has not been provided. As a result it is impossible to calculate the loss of water from the Loves Creek Catchment being drawn away and lost in an easterly direction as a direct result of groundwater extraction at Barwon Downs.

For human consumption the most important period of the year for water utilisation in the Catchment is during the drier summer months of little rainfall. Unfortunately this is the period when the flows in the creeks are at their lowest and depend largely on over flow from the aquifers. During this period water availability for stock consumption is vital. The streams in the Catchment have traditionally low summer flow. However, they have continued to flow throughout this worst drought on record. In 2008 Maxwell<sup>(7)</sup> calculated that the summer flow due to groundwater discharge was between 0.6 and 1.8 ML/day. Using 1.2 ML/day as an average from Maxwell's calculations, the following scenario realises an alarming outcome. When comparing the data collected for **stock and domestic use only** it is abundantly clear that the surface water in the Loves Creek Catchment is already over allocated.

- 90 days over the dry period of summer would have 108 ML flow down the Loves Creek system.

- If all of the stock and domestic users were to take their full allocation of 116.3 ML during this same period Loves Creek could be dried up for the entire 90 days.
- If for argument sake any one of the 50 (plus) stock and domestic users extracted their 2.2 ML on any one day this would be enough to dry the creek up.
- Even if on the same day each entitled landholder extracted a fraction of the flow in the Loves Creek system this could also be enough to dry out the creeks and streams in the Catchment.
- Added to this bleak picture is the fact that there are other landholders still to be interviewed who are likely to have stock and domestic water extraction rights.
- At least one of the irrigators has the right to pump at any period during the year. If exercised during summer this would accentuate the problem. In fact exercising this licence could by itself dry up the Loves Creek system.



**Porcupine Creek – middle of summer.** It would take little to cease this flow. Other Loves Creek Catchment streams have similar low summer flows.

Even if the daily average flow in Loves Creek of 2.2 ML/day that was calculated back in 1990/1994<sup>(2)(3)</sup> during “normal” pre-drought winters was used, the streams within the Catchment would be little better off. The surface waters in the Catchment are arguably well and truly **fully allocated** and most likely **over allocated**.



Ten Mile Creek –middle of summer

The availability and utilisation of the water resources in the Catchment for fire protection and prevention is crucial. If the multitude of peat beds and streams were to dry out the potential for unpredictable and long-burning fire events as evident along Boundary Creek, is extremely concerning and too frightening to contemplate.

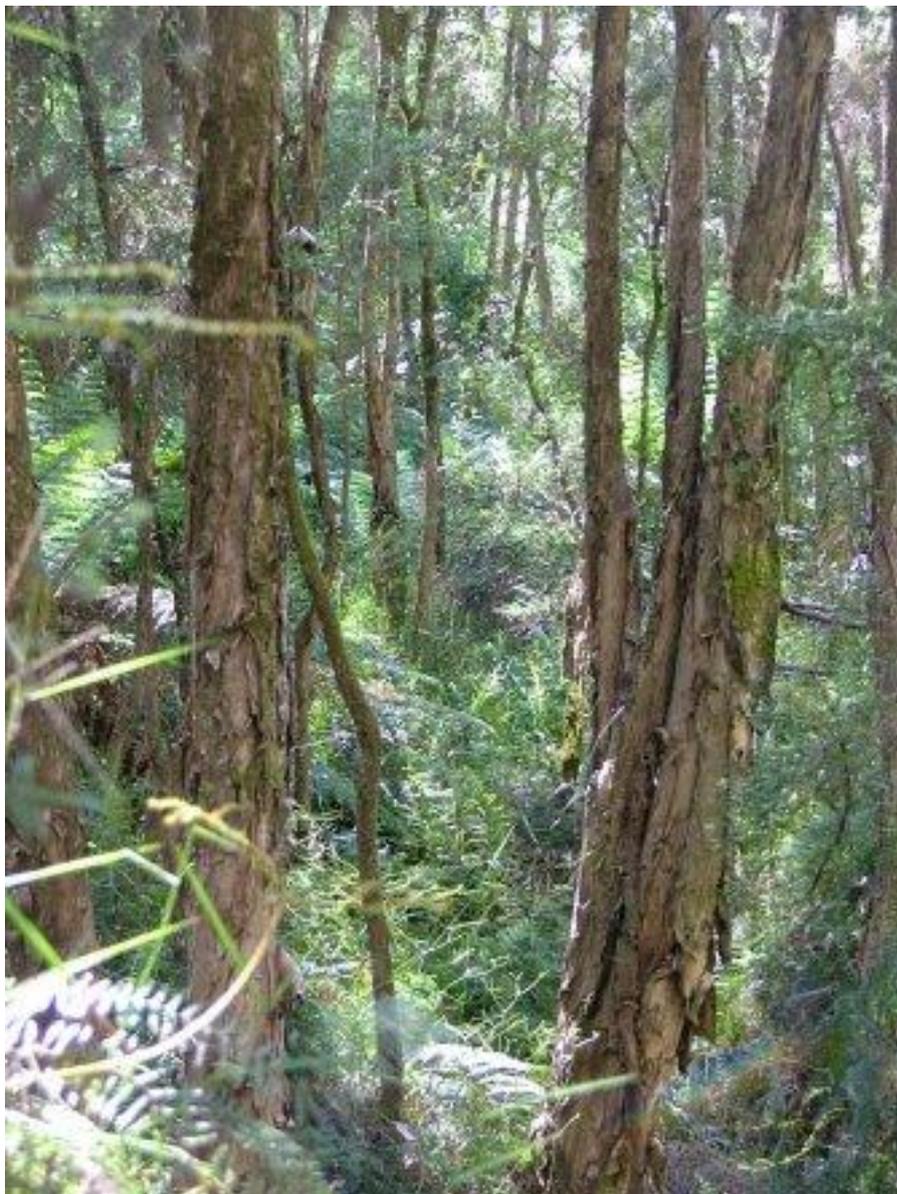
The utilisation of the water resources to sustain commercial enterprises, domestic activities, stock and social wellbeing cannot be over emphasised.

All homes in the Loves Creek Catchment are, from a water perspective, totally self reliant. Water is caught and stored in tanks, pumped from a bore, pumped from creeks, springs and dams. Many of these dams are spring fed. In 1989 the Rural Water Commission spring survey of the Kawarren area ascertained that of the few springs surveyed, 5 of them were from the Eastern View Formation deep water aquifer.

There is one licensed bore in the Catchment. Data on this bore was not forthcoming. How the bore is operated, the drawdown effects it may have, from which aquifer it is drawing etc. was not able to be ascertained.

Having at least 76 hectares of permanent wetlands on private property is significant. If wetlands located on public land could be calculated and were to be included, this figure would be considerably higher (estimated at 125 hectares). The importance of these wetlands has not been calculated and their significance to the well-being of the Catchment can only be surmised. However, it is known that the wetlands in the headwaters of many of

the creeks in the Catchment are fed from an overflow from deep to shallow aquifers. This overflow in turn feeds the summer flows in the streams of the Loves Creek Catchment. The total overflow from these many springs and wetlands amounts to a small but critical amount of water. Groundwater extraction could quickly and easily upset the natural balance of this overflow. As already discussed the groundwater sustains the summer surface flows and is already accounted for before it reaches the surface.



Healthy Ten Mile Creek wetlands overflowing into the Ten Mile Creek.

As Maxwell<sup>(7)</sup>(2008), calculated this amounts to between 0.6 & 1.8 megalitres a day from a Catchment area of 83 square kilometres. This natural balance that has taken eons to arrive at is no doubt being disturbed as a result of the present drought, probable drawdown from the Barwon Downs borefield and or climate change. However, the fact remains that the basic integrity of Loves Creek Catchment has been maintained with groundwater discharge into the wetlands, springs and creeks.

Evans<sup>(1)</sup> states that an important area of data collection is the establishment of stream flow gauging stations. In the mid 1990s three stream flow gauging stations were decommissioned. These stations collected this vital stream flow data that Evans refers to and their fully calibrated re-instatement must be considered in order to account for and calculate accurate flows.

## CONCLUSION

There can be little doubt that on the data so far collected, both the surface and ground waters are at the very best fully allocated and at the worst over allocated. Water use within the Catchment is considerably higher than ascertained in this Plan, given the conservative nature by which the consumption figures were calculated. The only possibility for any additional licence is for winter extraction from streams during high flow periods. And then the water must be stored in off stream storages. However, this will impact on Beneficial Uses downstream of the Loves Creek Catchment and appropriate considerations made.

Loss to adjoining catchments through groundwater borefields outside the Loves Creek Catchment is a serious threat to the security of the flows in the Loves Creek Catchment streams. This insidious draining from aquifers within this Catchment requires close scrutiny.

Considering the reliance on groundwater flows to maintain **wetland integrity** and **summer stream flow** there is an extremely compelling case for no groundwater extraction within the Catchment **OR** from adjoining catchment borefields that impact on this Catchment.

There are numerous tasks that require attention to ensure that the integrity of the Loves Creek Catchment is maintained and where possible improved. If implemented, the following recommendations would be a step in this direction.

## Recommendations for Future Action

1. Allow no further allocation of surface or groundwater in the Loves Creek Catchment.
2. Continue with the data collecting through personal visits with the intention of involving as many residents in the Loves Creek Catchment as is practical.
3. Investigate the feasibility and desirability to involve Beneficial Uses recipients from outside the catchment.
4. Continue attempts to involve Government authorities with catchment and natural water resource responsibilities.
5. While facilitating a better working relationship with regulatory bodies that influence matters within the Catchment, aim at creating *“a necessary reality check and knowledge base so that relevant ministers and other department officials can have confidence in its advice.”* (Bobbie Brazil – Chairman Landcare Council 2008)
6. Lobby the “authorities” to instigate a government funded Total Water Balance audit of the Loves Creek Catchment.
7. Conduct detailed long term studies to include both field and “desk top” information gathering on flora, birds, mammals, reptiles, amphibians, fish and freshwater macro invertebrates from the terrestrial ecosystems and the flora and fauna from the both the surface and groundwater ecosystems. Include the following studies...
  - A. Determine an environmental flow regime for at least sixteen terrestrial indicator species that includes a mix of 4 fish, 4 water invertebrates, 4 flora species and 4 benthic algae that are groundwater dependent.
  - B. Identify at least 5 fauna species that are found in the aquifer as indicators of the aquifer health.
  - C. Determine the occurrence and abundance of these species including their conservation status.
  - D. Compile an inventory of the habitat and biological needs of these species required to ensure their ecological survival.
  - E. Plan for verification of the environmental flow requirements of these species 5 years hence.
  - F. Collect inventories of all other species in the study area.
  - G. Asses the status of all species.
  - H. Compile detailed information on the occurrence and abundance of rare, threatened and endangered species.
  - I. record introduced species found in the wild.
  - J. A report on the effects of human extraction of water resources from the catchment that has an influence on the environmental values of the area.
  - K. Define those species studied that are partially and totally dependent on groundwater.
  - L. Note the species most susceptible to change in the water regime of the area.

- M. Determine and note those species living with connectedness to water tables, springs, soaks and wetlands
- N. Set up a bore monitoring network specifically designed to monitor sites that have groundwater dependent species.
- O. Develop and provide accurate comprehensive maps that clearly mark the areas of investigation.
- P. Note on these maps the creeks, springs, soaks, wetlands and peat areas.
- Q. Indicate the creeks, springs, soaks, wetlands and peat areas being monitored.
- R. Collect data that includes seasonal and yearly fluctuations.
- S. Describe all species by scientific and common name(s).
- T. Investigate the notion that small streams act as breeding grounds for biota that in turn are flushed into and replenish depleted stocks in larger creeks and rivers.
- U. Investigate the relevance to the Loves Creek catchment of this statement made by Evans<sup>(1)</sup> that “...*most river systems in Australia are nitrogen limited, i.e. their ecological health is controlled by the availability of nutrients. Surface water is typically nutrient poor while groundwater may often be nutrient rich. Hence, the discharge of groundwater into rivers is often controlling the health of their ecology.*”

An attempt to begin some of this work as outlined in point 7, has already been initiated. However, the need for closer scrutiny, scientific vigour and thoroughness will need to be applied.

- 8. Provide fish ladders at the Ten Mile, Porcupine and the Yahoo Creek stream flow gauging stations.
- 9. Survey the catchment for Potential Acid Sulfate Soils. This could be done when completing a comprehensive audit of springs and wetlands in the catchment as in point 7.P above.
- 10. Continue the work of fencing off stream frontages.
- 11. Endeavour to replace exotic species of vegetation in these stream side frontages with native species.
- 12. Facilitate environmentally friendly stock access to water resources.
- 13. Instigate a study aimed at ascertaining the influence and effects on the Loves Creek Catchment from drawdown influences by the Barwon Downs borefield extractions.
- 14. Develop a framework of accountability that is equitable to all Beneficial Uses. Up to this point the local landholder is easily held accountable for actions taken. There are sufficient regulations and authorities to enforce best practice. However, the same cannot be said for the authorities themselves. For example 6 megalitres of toxic polluted water was illegally extracted from the Kwarren borefield and released into the Loves Creek Catchment and the authority involved was not held accountable. If this same breach of the law had been done by a landholder the consequences would have been handled differently. Authorities and individuals have to be held accountable, abide by the law of the land and suffer the same retribution when the law is breached.

15. FUTURE PLANS to include LOCAL CONSULTATION. Any persons or authority making application to vary the water resource management within the Loves Creek Catchment is to consult with LAWROC or at the very least a significant number of residents in the Catchment. This would include such catchment management issues as riparian vegetation, river frontage management, fish stocking, salinity, weed control, spraying, willow removal and water resource allocation.
16. STREAM FLOW GAUGING STATIONS. Stations on Ten Mile Creek (235239), Porcupine Creek (235241), Yahoo Creek (235240) and Loves Creek (235234) should be maintained and kept in commission. The Porcupine, Ten Mile and Yahoo Creek stations were decommissioned in the mid 1990s. The Ten Mile and Porcupine Creek stations were recommissioned in 2008 in an ad hoc fashion. These stream flow measuring stations are vital data collecting points and must be calibrated and maintained, especially if accurate data is required in the future. Because of the low flow rates in these streams it is not adequate to “infill” missing data through extrapolation.
17. TRIGGER LEVELS. The above mentioned stream flow gauging stations should have trigger levels established. When reached landholders above the station should be notified and every possible attempt should be made to restrict water extraction to an absolute minimum. The only extraction past this point would be judicious use for stock and domestic.
18. DISPUTE RESOLUTION. Any disputes will be resolved in accordance with the Water Act 1989, Southern Rural Water policy and any other relevant Government policy.
19. REPORTING. Southern Rural Water to provide a yearly report on...
  - a. The full record of compliance to issued licences.
  - b. The annual amount of water diverted from the Loves creek catchment by entitled licence holders.
  - c. Any failures to comply with any licence conditions.
  - d. Actions taken with failures to comply with licence conditions.
  - e. Any significant amendments to any licence condition.
  - f. Any transfer of water from the Catchment including the place of origin and the destination.
  - g. Any water sales made from or within the Catchment.

## This is the Bibliography for APPENDIX FOUR

1. Evans R., April 2007: The Impact of Groundwater Use on Australia's Rivers – Exploring the technical, management and policy challenges. Technical Report Product codes PR071282 and PR071283. Land & Water, Australia, Australian Government. (Based on the Land and Water Senior Research Fellowship Report by Dr. Richard Evans, Principal Hydrogeologist, Sinclair Knight Merz.)
2. Hebblethwaite D. and James B., 1990: Review of Surface Water Data, Kawarren. Unpublished Rural Water Corporation Investigation Branch, 1990/45.
3. HydroTechnology, October 1994: Gellibrand Groundwater Resource Evaluation, Government Service Contract, CC/30420.001A/1
4. Khouri G., Duncan B. 1993: Otway Water Supply System Review. Catchment Management Services Report No. 1993/63. HydroTechnology.
5. Leonard. J., September 1984: Regional Water Strategy Plan for the South-Western Region of Victoria, Stage one, Augmentation of Geelong's Water Supply to the year 1995. A Submission to the Natural Resources and Environment Committee inquiry into Water Resources Management. Department of Minerals and Energy. Government Printer.
6. McPhail. I., 2008: Victoria 2008, State of the Environment – Summary. Commissioner for Environmental Sustainability – Melbourne, Victoria, Australia.
7. Maxwell. S., July 2008: Determination of Baseflow Contribution at Loves Creek within the Gellibrand Groundwater Management Area. OENG1040A – Integrated Workplace Project 1, Royal Melbourne Institute of technology.
8. Victorian Government, July 2007: Statement of Obligations – Barwon Region Water Authority. Water Industry Act 1994
9. Woodward Clyde, March 1999: Gellibrand Groundwater Management Area (GMA) – Permissible Annual Volume (PAV). Prepared for the Department of Natural Resources and Environment.
10. Zampatti B. and McGuckin J. 1995: Fish Populations and Environmental Flows in the Gellibrand River. Water Ecoscience Pty. Ltd., Mt. Waverley, Victoria. WES Report No.,:42/95.
11. Zampatti B., Bradshaw E. and Lewis K. 1996: Fish Populations and Environmental Flows in the Gellibrand River and Love Creek South Western Victoria. . Water Ecoscience Pty. Ltd., Mt. Waverley, Victoria. WES Report No, 100/96



**NOTE: The Bibliography for Book 16 is found on page 21.**