OTWAY WATER

The Impacts Resulting from the Big Swamp Drying Out.

BOOK 14

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May 2011

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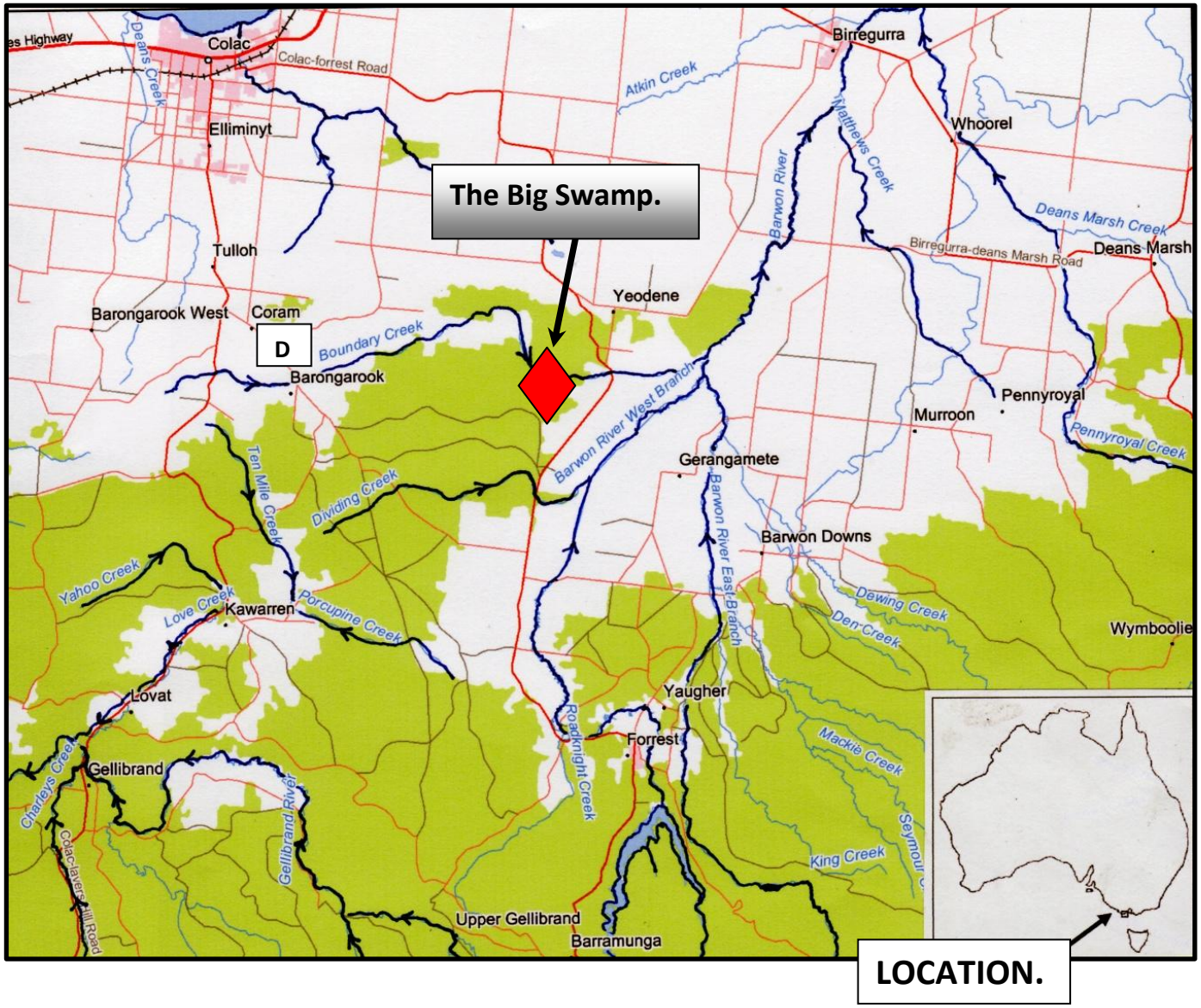
CONTENTS

INTRODUCTION

The Big Swamp was a wetland along Boundary Creek, a tributary of the Barwon River located in the Otway Ranges of Victoria, Australia. In a saturated anaerobic condition the combination of iron, anaerobic bacteria, sulfur, temperatures around 10^0C and a plentiful supply of organic matter, the production of significant quantities of pyrite accumulated in the Big Swamp. Over eons the flora and fauna of the Big Swamp evolved, flourished and peacefully survived under these saturated conditions. However since 1984, as the peat in the Big Swamp progressively dried out the environment began to undergo massive changes. The ecosystems that had existed for living memory eventually began to disappear. The impacts and destruction of the wetlands in the Big Swamp have been dramatic, complete and far reaching.

This Otway Water Book attempts to demonstrate the multitude of impacts and destruction that have taken place.


The Big Swamp.
Colac
Colac-forrest Road
Elliminyt
Tulloh
Barongarook West
Coram
D
Barongarook
Yeodene
Birregurra
Atkin Creek
Barwon River
Matthews Creek
Whoorel
Deans Marsh Creek
Birregurra-deans Marsh Road
Deans Marsh
Pennyroyal
Murroon
Pennyroyal Creek
Gerangamete
Barwon River West Branch
Barwon River East Branch
Barwon Downs
Dewing Creek
Den Creek
Wymboolie
Boundary Creek
Ten Mile Creek
Dividing Creek
Yahoo Creek
Love Creek
Kawarren
Porcupine Creek
Lovat
Yaugher
Forrest
Roadknight Creek
Mackie Creek
Gellibrand
Charleys Creek
Gellibrand River
Colaciaversill Road
King Creek
Upper Gellibrand
Barramunga
LOCATION.

CHAPTER ONE

The Big Swamp - 1912 and 1984.

The Boundary Creek Catchment in the vicinity of the Big Swamp was a thriving and healthy wetland up to the summer of 1984. From the Big Swamp to the confluence with the Barwon River, the Boundary Creek wetlands supported a diverse collection of water dependent flora and fauna. Platypus and native blackfish were abundant. The Big Swamp wetlands were “jungle” like, supporting many water dependent flora, fauna and fungi species.

Farmers downstream had a secure and reliable source of fresh water. The agricultural flood plains maintained a green summer pick for stock and the stream banks maintained their stability. The boggy dense wetlands of the Big Swamp did not have to be fenced out as domestic stock would not enter the saturated, treacherous peats.

Since European settlement numerous attempts to drain these peaty Big Swamp wetlands had failed. Fire reduction burns never entered the saturated areas. The water dependent ecosystems within the wetlands of the Big Swamp were known to have remained relatively stable since 1912. The waters flowing out of the Big Swamp into Boundary Creek had been the salvation of farmers through many serious droughts. Boundary Creek below the Big Swamp was historically known as a reliable and permanently flowing stream.

These pictures were taken in the lower reaches (see point A page 11) of the Big Swamp late in 2008. Although beginning to suffer from the drying out of the peat and with water pH below 3 these photographs give some indication how the entire area of the Big Swamp would have looked pre 1984.

CHAPTER TWO

Acid Sulfate Soils in the Big Swamp.

"***Soil health is the capacity of soil to function as a vital living system, within ecosystem and land-use boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and promote plant and animal health.***"(46)

Soil organisms are a vital part of a healthy soil environment. These organisms provide beneficial soil and ecosystem functions such as water storage, detoxification of toxicants, suppression of noxious and pathogenic organisms, and decomposition and nutrient recycling. Healthy soils are crucial supporting and maintaining human and ecosystem health.

Healthy soils are productive, sustainable, profitable and underpin key ecosystem functions and human wellbeing. However, soils are sensitive to land management practices often succumbing to degrading soil processes such as salinity, erosion, compaction, water logging and acidification. It is known that 25 000 ha of coastal Victoria have the potential to contain acid sulfate soils that cannot be disturbed without comprehensive management. Little has been done to determine the degree of Inland Acid Sulfate Soils (IASS) but it is known that IASS have the potential to be extremely destructive to soil health if disturbed and unregulated.

The soil health balance in, and below the Big Swamp has in human health terms, become chronic approaching a terminal status.

Acid Sulfate Soils.

The name given to soils and sediments that contain iron sulphides is Acid Sulfate Soils (ASS). The term Acid Sulfate Soils includes both Actual Acid Sulfate Soils (AASS) and Potential Acid Sulfate Soils (PASS). AASS and PASS quite often occur in the same soil profile with the AASS usually overlying PASS.

Potential Acid Sulfate Soils.

Potential Acid Sulfate Soils are formed when sulfate, iron oxides and organic matter are present in a waterlogged situation in the absence of oxygen. The most common iron sulfide in Acid Sulfate Soils is pyrite (FeS_2, - iron disulfide). Pyrite is relatively abundant in the stratigraphic sequence particularly in the upper Dilwyn aquifer formation. The Dilwyn and Pebble Point formations outcrop in much of the sands of the Barongarook High region including Boundary Creek and the Big Swamp.

In anaerobic conditions, given a temperature above 10^0C, certain bacteria flourish using sulfate instead of oxygen during microbial respiration, helping to produce pyrite. If maintained under anaerobic conditions by permanent groundwater, the iron sulfides are relatively benign. These soils are called Potential Acid Sulfate Soils (PASS).

Actual Acid Sulfate Soils.

Pyrite is most often microscopic and has a very large surface area and will react rapidly when exposed to oxygen. Any iron sulfides present reacting with oxygen, water and aerobic bacteria will produce a variety of iron compounds and sulfuric acid. Many reactions take place during this process and the resulting compounds are very environmentally unfriendly.

If the pH levels drop below 4, ferric iron produced in earlier acid forming processes, can remain in solution and greatly accelerate the rate of pyrite oxidation. This acid producing process can continue in the absence of oxygen and may even continue after Acid Sulfate Soil is rewetted.

Any iron oxy/hydroxides produced in this acidification process can break down and produce additional acid that can be released without the need of oxygen, usually through hydrolysis.

In addition to the release of acid and the lowering of the pH levels, the activation of sulfidic materials found in Potential Acid Sulfate Soils, can lead to significant increases in dissolved metal concentrations.

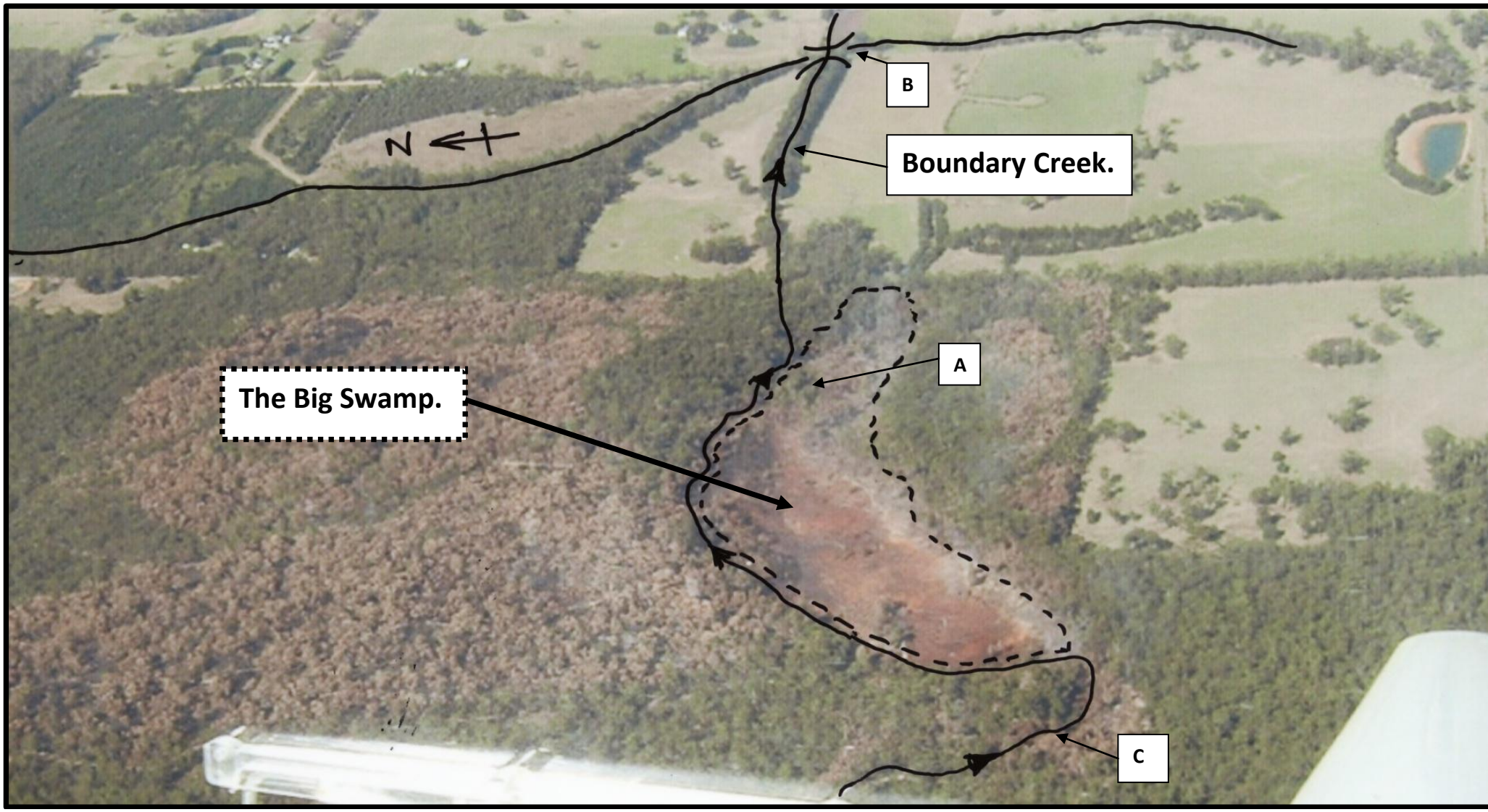
Noxious odours can be evident at each phase of the Acid Sulfate Soils process.

The Big Swamp - 1984 to 2010.

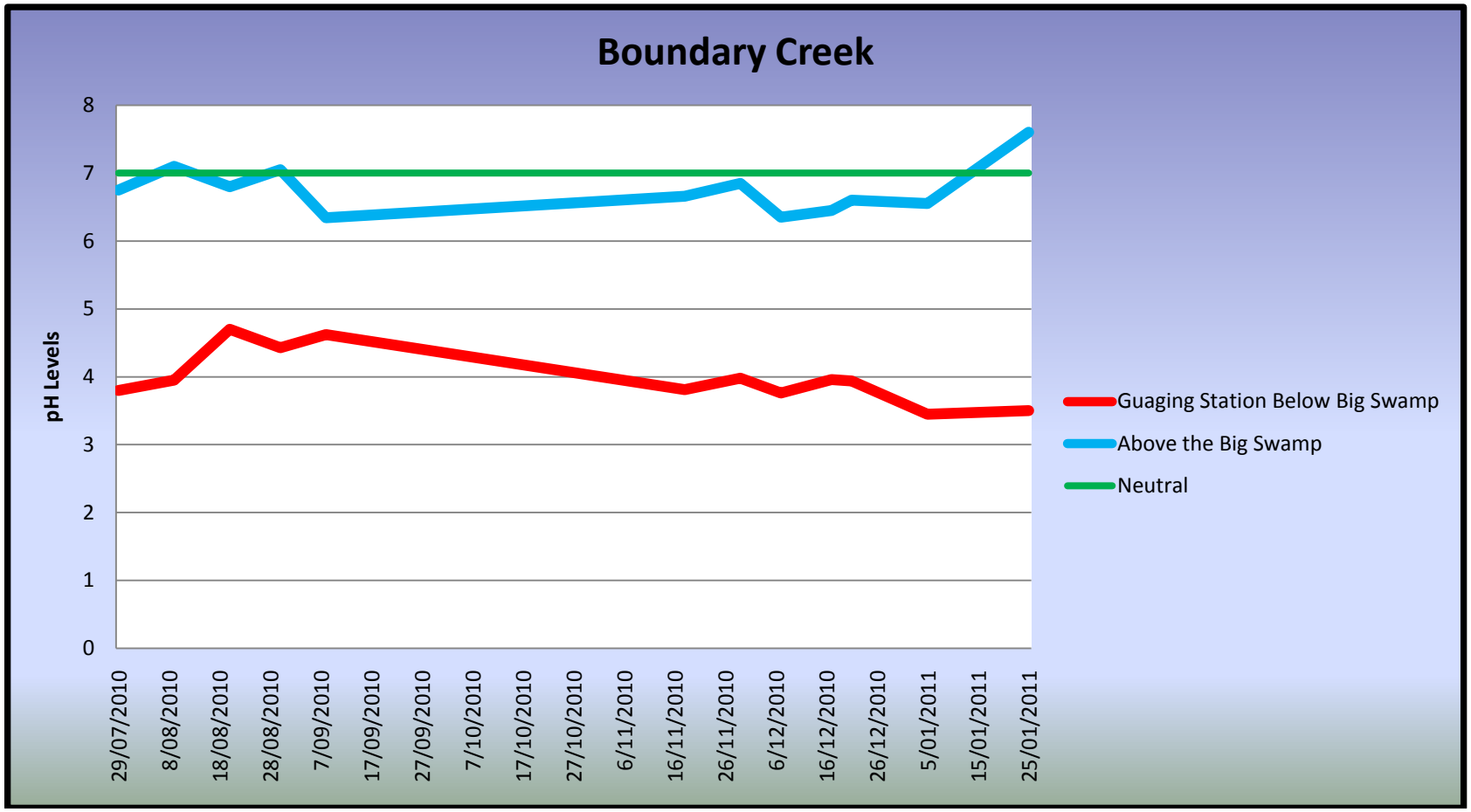
Sometime at the beginning of the early 1980s the Big Swamp began to dry out. Local farmer records indicate that Boundary Creek stopped flowing for the first time in the summer of 1984. When the water table level was higher than 158 metres Australian Height Datum (AHD), the Big Swamp would remain saturated and Boundary Creek would continue to flow. However, as the water table fluctuated around the 158 m level or lower, the drying out of the Big Swamp and flows in Boundary Creek would have been spasmodic. The upper sections of the wetlands and Boundary Creek would remain dry until there were significant rainfall episodes. However, despite these rains the water table continued to drop and the dried out area of the wetlands increased as a result. By 2010 the depth of dried out peat was in the order of many metres.

In the late 1980s the peat depth was estimated between 2 and 8 metres. However, after the peat caught on fire in 2010 the Country Fire Authority (CFA) put the depth in some areas of the swamp round the 20 metre mark. The surface area of the Big Swamp has been calculated by the CFA, to be approximately 7 hectares.

The potential for the Big Swamp to generate acid and associated side effects is enormous.
"***The extremely low pH levels of 3.0 to 3.5 in waters discharging from the area is equivalent to pH levels seen in mine dumps and slime dams caused by oxidation of mineral sulphides in waste ore from base metal mines***, " Roger Blake (pers. com).



Aerial photograph –John Callahan (After the 2010 fire).



The water flowing into the Big Swamp (blue line- see point **C** page 11) is close to neutral, sometimes slightly acidic and sometimes slightly alkaline. After flowing out of the Big Swamp area past the stream flow gauging station on the Colac to Forrest Road Bridge, the water is considerably more acidic, in the order of 1000 to 10 000 times more acidic than when it enters the Big Swamp region (red line – see point **B** page11).

CHAPTER THREE

Bacterial Scum.

During the initial chemical reactions as the sulfides oxidise the process is accelerated by bacteria such as Thiobacillus ferrooxidans. Bacterial activity produces waste products that can often be seen on the surface of streams as a scum. This scum is quite different to an oily scum as it does not readily stick to any item moving through it. Poking a stick through bacterial scum will not pick up the residue on the stick like oily scum. Bacterial scum will separate and then reform once the stick is removed.

The bacterial scum or waste product can form a blanket over the surface water of a stream. **(Also see page 45 – scum not apparent around a dead eel).**

CHAPTER FOUR

Monosulfidic Black Ooze (MBO).

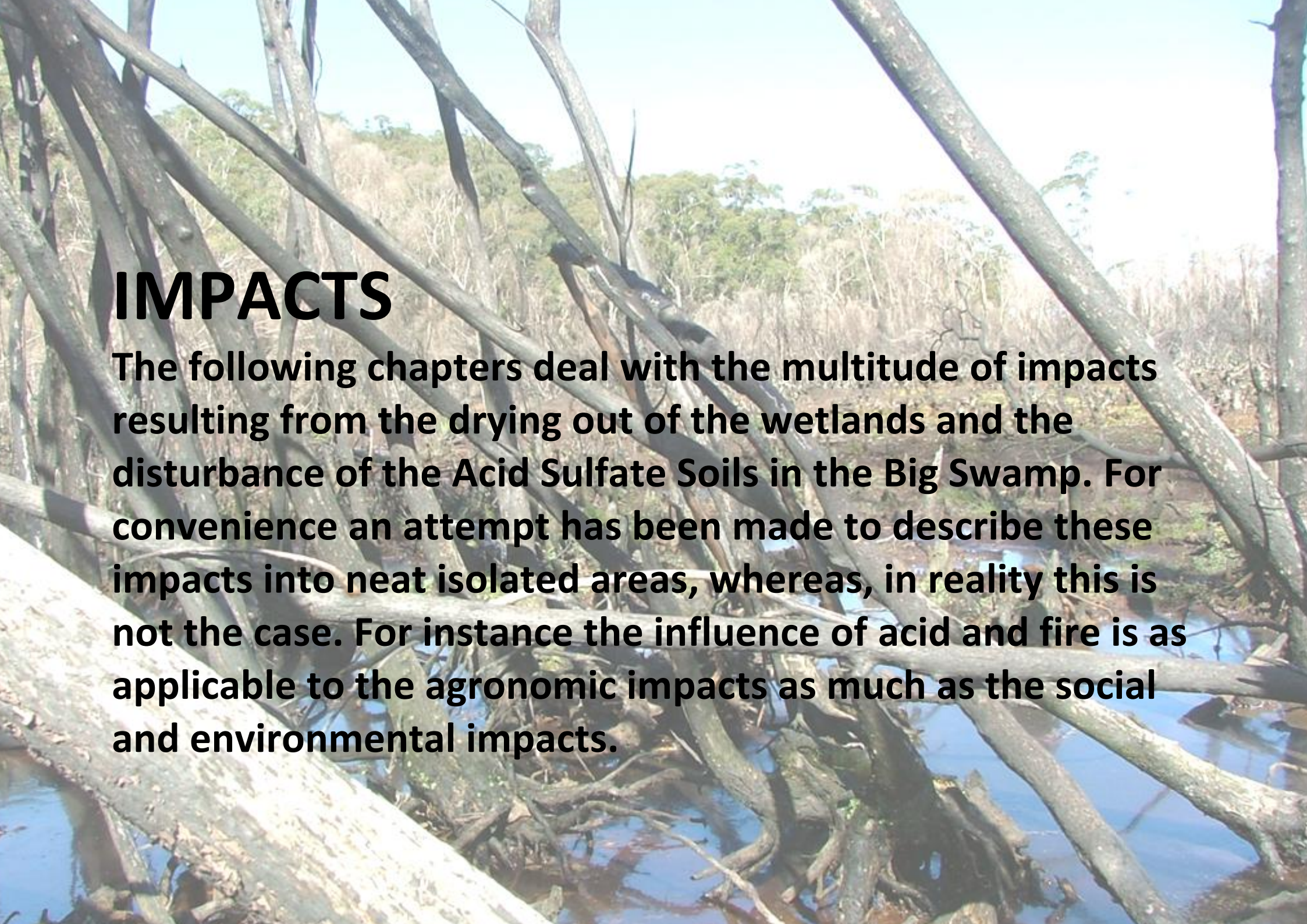
Monosulfidic Black Ooze is a highly reactive organic-rich material that can be found in the beds of water environments. Provided this material remains in an anoxic condition it is relatively benign. MBOs are commonly enriched in ultra-fine reactive iron sulfides that are produced during the formation of pyrite (FeS_2). Some of these iron sulfides are amorphous (FeS), greigite (Fe_2S_3) and mackinawite (Fe_9S_8).

The bi-products of algae and microbial organism activity can also be present in the formation of these black smelly deposits. When disturbed and resuspended in a water column, the thick accumulation of MBOs quickly oxidise sucking the oxygen out of water. This can also cause severe additional acidification. In flood episodes this MBO can be a component of "Black Water."

When the dissolved oxygen levels plummet, this can cause the release of sulfide and ammonia in toxic levels, to be released from bed sediments.

Monosulfidic Black Ooze is most often found in the beds of waterways in and below the vicinity of Acid Sulfate Soil sites.

This photograph of Monosulfidic Black Ooze was taken in the stream bed of Boundary Creek below the Colac to Forrest Road Bridge (see point B, page 11).



IMPACTS

The following chapters deal with the multitude of impacts resulting from the drying out of the wetlands and the disturbance of the Acid Sulfate Soils in the Big Swamp. For convenience an attempt has been made to describe these impacts into neat isolated areas, whereas, in reality this is not the case. For instance the influence of acid and fire is as applicable to the agronomic impacts as much as the social and environmental impacts.

CHAPTER FIVE

Agronomic Impacts.

Soil health is fundamental to the viability and integrity of agricultural ecosystems and underpins the agricultural productive base for Victoria's well-being. Any decrease in soil health will affect agricultural productivity, devalue a natural asset and can be extremely serious. In some instances this deterioration can take an insidiously long time to manifest. Small changes over an extended period tend to be accepted just as changes in a growing child are not as noticeable to the parents as they are to an irregular visitor. Farm properties can change hands and the new owners accept the conditions of the recently acquired land as the way things have always been.

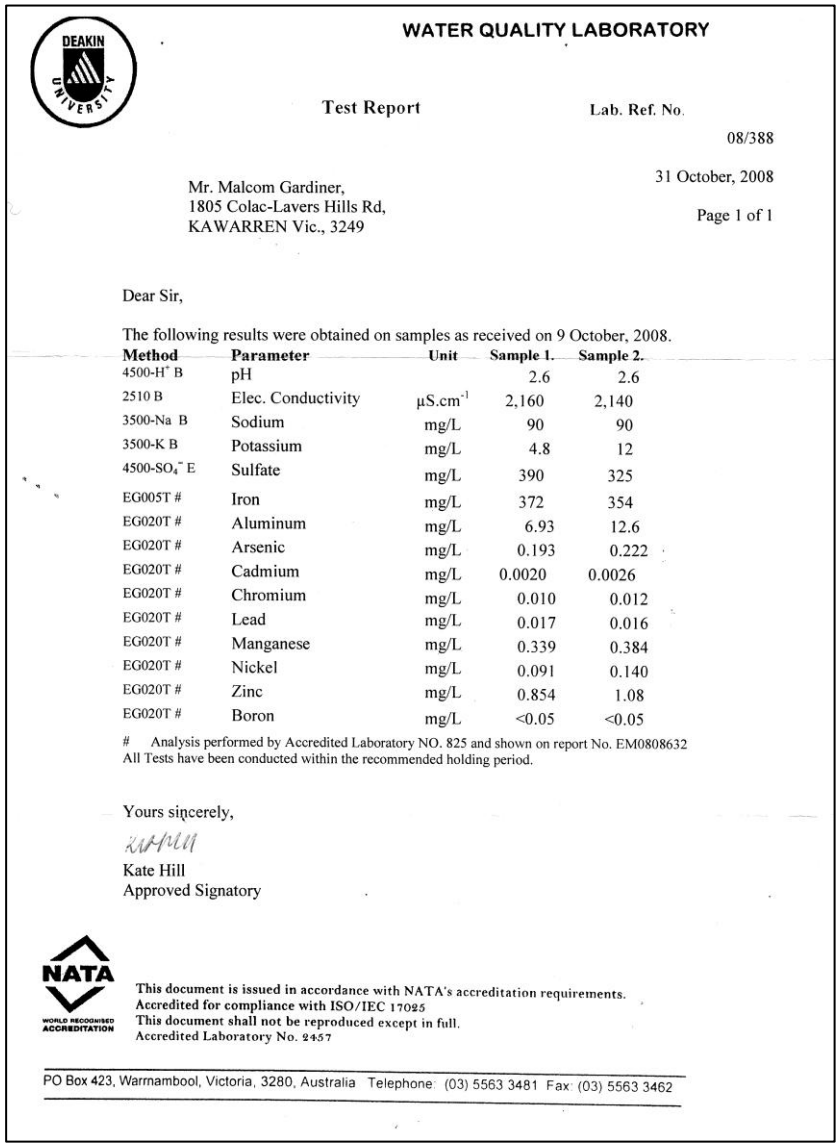
Adjustments are made to farming management as new problems arise. In some cases the underlying problems are not readily apparent and tend to go unnoticed. For instance, Nellie Shalley would not allow her stock, in recent times, to drink from Boundary Creek until there had been a 100 – 125 mm rainfall flushing out of the system (pers. com). Before the Big Swamp began to dry out the water was suitable for animal consumption all year round and had been so for decades going back to 1912. Since the 1990s Nellie knew there was a problem and made necessary adjustments to her farming practices.

Boundary Creek December 2007.

Eventually, there came a time when the impacts of the drying out of the wetlands placed considerable hardship and financial burden on farming enterprises below the Big Swamp. During the winter of 2010 the water coming out of the Big Swamp was consistently 1000 times more acidic than the water going into it **(see graph page 12)..**

Boundary Creek had been an all year round water source critical to the viability of farms relying on this permanent water supply. From 1984 Boundary Creek started to have days of no flow and as a

consequence dams had to be constructed at considerable costs and farming practices changed. Then the acid generated in the drying peat began to have its affect.



WATER QUALITY LABORATORY

Test Report

Lab. Ref. No. 08/388

31 October, 2008

Page 1 of 1

Mr. Malcom Gardiner,
1805 Colac-Lavers Hills Rd,
KAWARREN Vic., 3249

Dear Sir,

The following results were obtained on samples as received on 9 October, 2008.

Method	Parameter	Unit	Sample 1.	Sample 2.
4500-H^+ B	pH		2.6	2.6
2510 B	Elec. Conductivity	$\mu S.cm^{-1}$	2,160	2,140
3500-Na B	Sodium	mg/L	90	90
3500-K B	Potassium	mg/L	4.8	12
4500-$SO_4^{=}$ E	Sulfate	mg/L	390	325
EG005T #	Iron	mg/L	372	354
EG020T #	Aluminum	mg/L	6.93	12.6
EG020T #	Arsenic	mg/L	0.193	0.222
EG020T #	Cadmium	mg/L	0.0020	0.0026
EG020T #	Chromium	mg/L	0.010	0.012
EG020T #	Lead	mg/L	0.017	0.016
EG020T #	Manganese	mg/L	0.339	0.384
EG020T #	Nickel	mg/L	0.091	0.140
EG020T #	Zinc	mg/L	0.854	1.08
EG020T #	Boron	mg/L	<0.05	<0.05

Analysis performed by Accredited Laboratory NO. 825 and shown on report No. EM0808632
All Tests have been conducted within the recommended holding period.

Yours sincerely,

Kate Hill
Approved Signatory

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PO Box 423, Warrnambool, Victoria, 3280, Australia Telephone: (03) 5563 3481 Fax: (03) 5563 3462

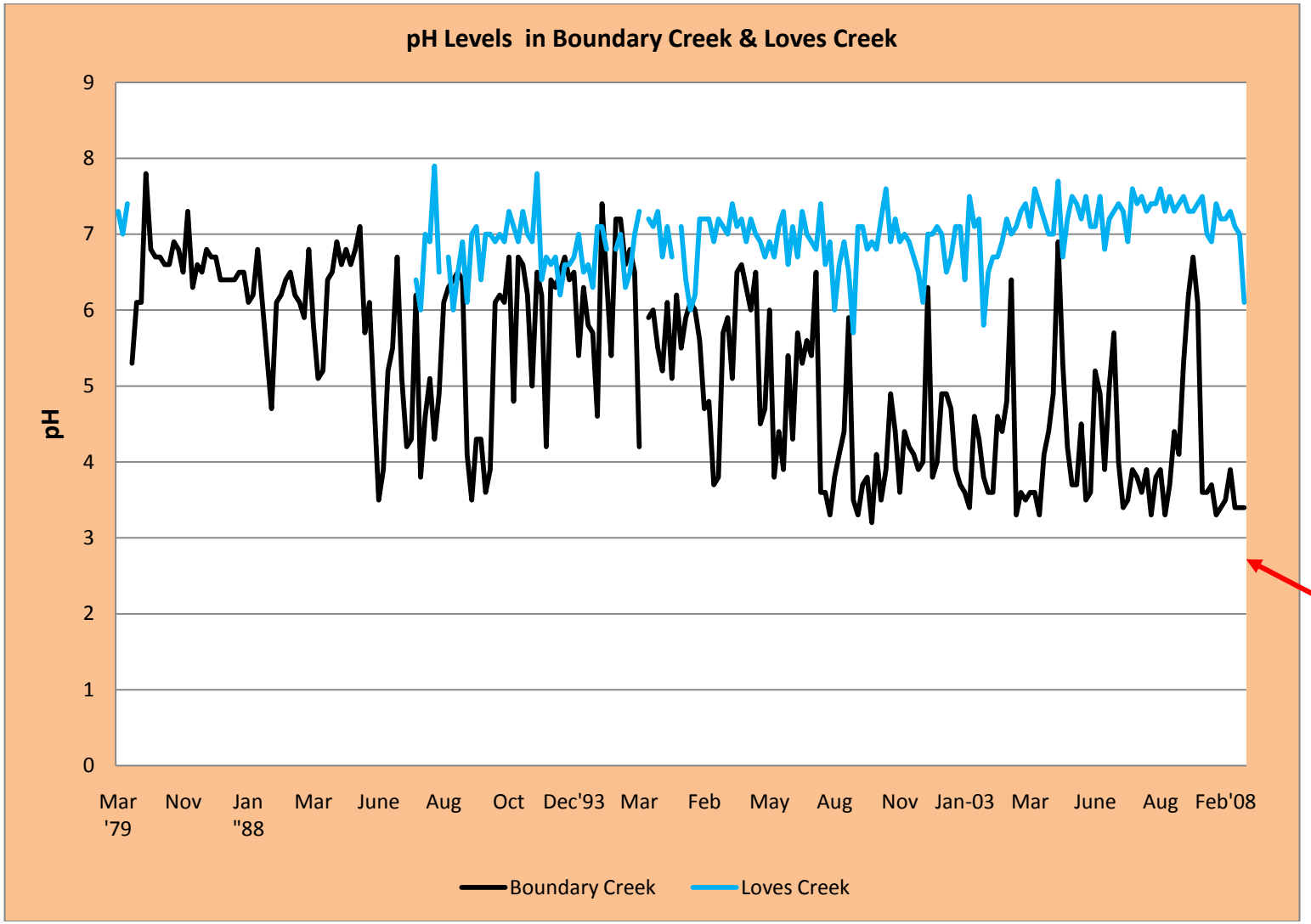
Low pH associated with Acid Sulfate Soils (ASS) can include toxicities, such as aluminium, iron, arsenic, lead, zinc and manganese.

These test results of water taken from the Big Swamp area, indicate that these toxicities do exist. The concentration and periods of toxicity appear to fluctuate depending on the amount of rainfall flushing through the Big Swamp.

The Australian & New Zealand Guidelines for water quality Criteria and Exceedances list the Arsenic level at 0.024 mg/l. The results obtained in 2008 are far in excess of this. Chromium, iron, lead, nickel and zinc also exceed these guidelines.

2009 -10 test results confirm that there can be no doubt the waters coming from the Big Swamp contains concentrations of toxins detrimental to animal and human health.

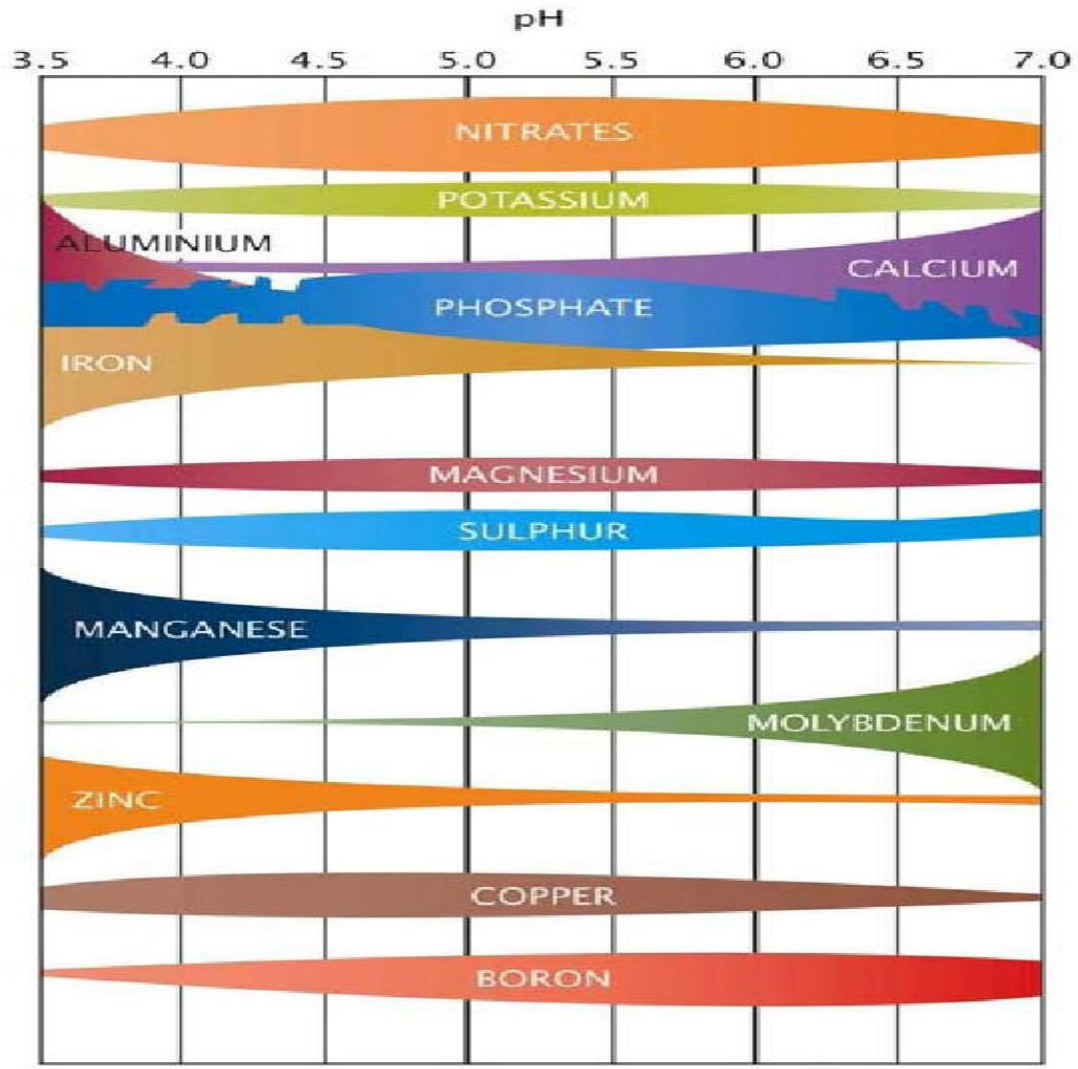
Boundary Creek waters display a progressive drop in pH levels over the years (see page 19).



The Upper Barwon Landcare Network reading of Boundary Creek in June 2010 was 2.8 pH.

The Boundary Creek graph should mirror the Loves Creek graph.

Diagram Source: Acid Soils fact sheet Glenelg Hopkins Catchment Management Authority & Department of Primary Industries, Victoria.



This diagram demonstrates the effects the drop in pH levels can have. Note this only goes down to a pH level of 3.5. Test results on the Boundary Creek water have been as low as 2.5 pH. That is 10 times more acidic than shown on this diagram.

As the pH drops this can lead to phosphorous, potassium and calcium deficiencies and or availability. Combined with the elevated levels of aluminium the likelihood that productive pasture species will dramatically decline is extremely high.

Colonisation of affected pastures by more tolerant species to the altered conditions would see a drop in productivity. The task of returning pasture to an economic productive base would in all probability be time consuming, lengthy and expensive.

Even before the discovery of an Inland Actual Acid Sulfate Soil site located in the Big Swamp Cr. Peter Mercer of the Colac Otway Shire, was cognisant of problems that would affect farmers if the water resources were not managed better. This insight was based on the fact that productive farmlands could not survive without a reliable water source and issues within the Shire indicated a different approach to water management was required.

In the Geelong Advertiser 28 August 2008, it was reported that Cr. Peter Mercer had spoken at a Colac Otway Shire Council meeting regarding the water management issues that were arising in the Shire. He expressed the view that water management issues had to become as much the Shire's responsibility as water harvesting was threatening the viability of the Shire.

> "***Are we to watch our dairy farms, organic orchards, blueberry farms and other food producers have their viability threatened.***"

There was also an article in the Colac Herald 29 August 2008 headed, "**Big cities threaten production of food**." As a civic leader Cr. Mercer echoed his opinion that "...*over pumping of the aquifers* (at Barwon Downs) *risked the environment, agriculture, people's health and economy*."

Vegetable Production

For extended periods the use of water flowing out of the Big Swamp and down Boundary Creek is no longer suitable for vegetable production.

Bore Water

As levels in the aquifer under the Big Swamp drop, properties and characteristics of the hydrology of the area change. The use, reliability and quality of bore water can be seriously threatened.

Scalding

Acid flowing over pasture can scald and kill the grass.

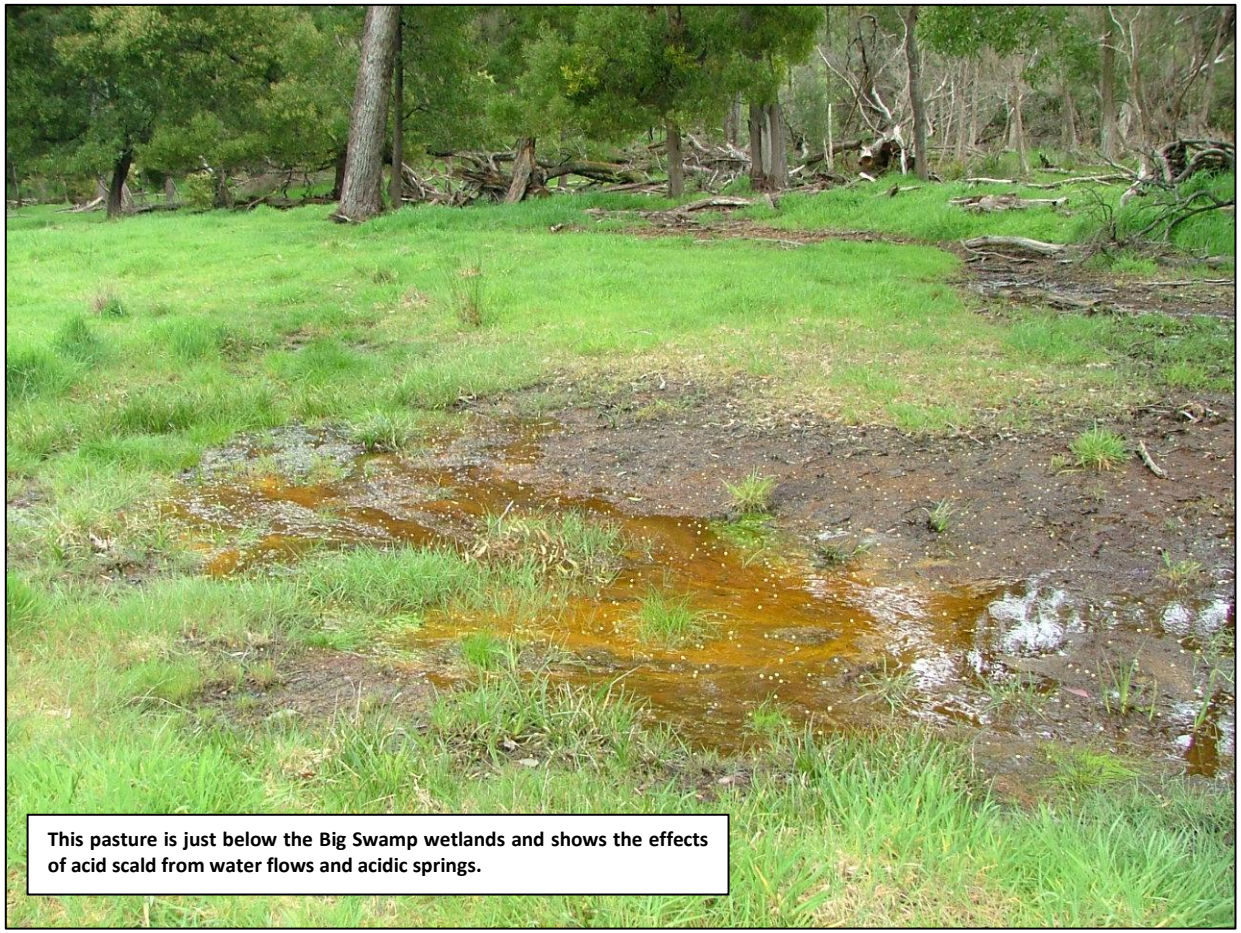
Acid Creep

As the influence of acid generation in the peat spreads, the likelihood of acid creep through the pasture producing areas will also increase (also see page 27).

Animal Health

Stock grazing this pasture and drinking the water can lead to unhealthy animals reducing productivity, reduction in income and an increase in costs.

High levels of aluminium, iron, zinc and manganese can affect the biochemistry of animal cells leading to signs of sickness, ill health and poor growth. Arsenic and lead are very toxic to most animals. Lead is a cumulative poison and can cause diarrhoea, dizziness and chronic debilitating ill health. Arsenic can be absorbed quickly into the body and can also be rapidly excreted and released from stock by way of urine and in the case of dairy cows in the milk. In this way arsenic can enter the human food chain (pers. com Michael Rhodes- Veterinarian).



This pasture is just below the Big Swamp wetlands and shows the effects of acid scald from water flows and acidic springs.

Infrastructure

Farming infrastructure such as pumps, bridges and piping can be seriously affected from corrosion.

Pastures

Pastures on the flats of Boundary Creek below the Big Swamp would on most occasions remain green and provide a summer food source for stock.

Fire

However, the reverse has become the norm with summer green pick disappearing and the chances of occurrence and intensity of fire episodes markedly increasing.

Pollinators.

Soil health deterioration, gases and dust from the Big Swamp represent a potential threat to the populations of pollinators so necessary and critical in the agricultural industry.

Food Tainting.

Gas and dust emissions also present a potential threat to above ground produce such as grapes and vegetables.

The breakdown of soil health in the wetlands and below the Big swamp represents a serious threat to the agricultural productive systems.

CHAPTER SIX

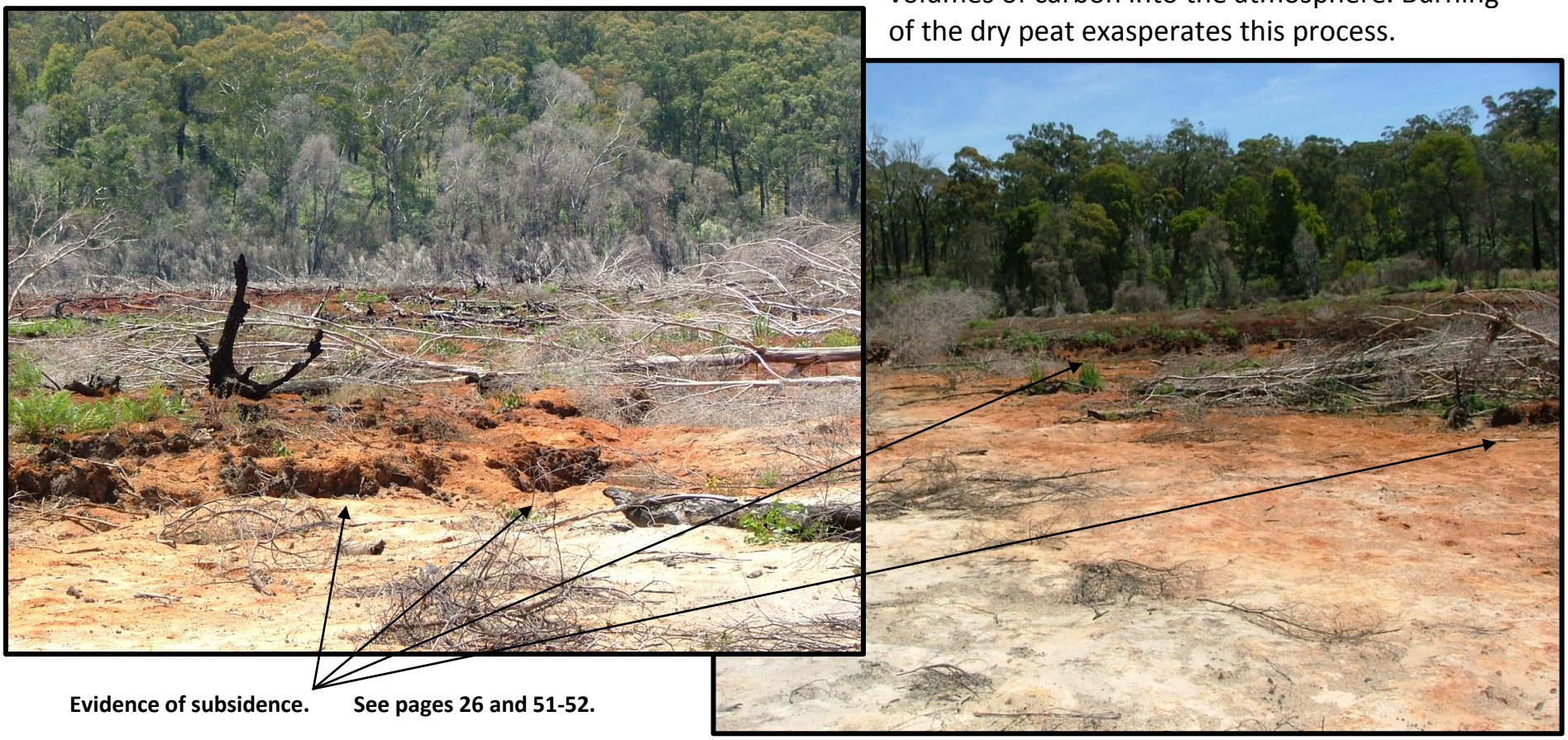
Corrosion.

The pylons on the Colac to Forrest Road Bridge have been reported as suffering from concrete corrosion as a result of infrequent submersion.

CHAPTER SEVEN

Subsidence and Carbon Release.

Wetlands in an undisturbed state are natural accumulators of carbon. However, as the peat dries out it begins to oxidise, shrink and compact, often reducing in volume by half. During this process emission of gases take place, one of them being carbon dioxide. The wetlands change in character from being a carbon positive to carbon negative area, releasing huge volumes of carbon into the atmosphere. Burning of the dry peat exasperates this process.



Evidence of subsidence. **See pages 26 and 51-52.**

These two pictures show the effects of peat subsidence and the influence of fire. The peat that originally covered the roots of these plants has been reduced by at least 80 centimetres.

Photograph taken after the 2010 fires.

Glomalin

"Glomalin was discovered in 1995 by US soil scientist Dr Sara Wright. It is a sticky protein produced by root dwelling mycorrhizal fungi that is sloughed off into soil by growing roots. By gluing soil particles and organic matter together, it stabilizes carbon and keeps it from escaping into the atmosphere. The mycorrhizal require living roots to function and perform better in undisturbed soil. Glomalin is a major component of soil organic matter and is thought to account for 27% of carbon in soil. It is found in soils throughout the world, with research indicating that some soils have the capacity to store large amounts of carbon in Glomalin with long turnover rates."(122)

Result of the 1998 fires – photograph taken in 2009. After 12 years the area in the foreground had failed to regenerate. The 2010 fire began somewhere in this vicinity.

Subsidence and root exposure is evident and acid creep downstream is seen to be influencing the vegetation in the background.

CHAPTER EIGHT

Social Impacts.

The impacts associated with the disturbance of Acid Sulfate Soils are also of a social nature:

- health (toxic water, toxic gases and reduction of healthy pastime & recreational pursuits),
- diminished economic productivity,
- diminished food production,
- increased risk of fire and intensity, and
- community displacement.

Toxic Water.

Acid levels as low as 2.5 pH that are regularly flushed down the Boundary Creek system and into the Barwon River are by themselves a serious risk to human health without considering the multitude of heavy metals. Aluminium has been tested at 9.8 times above the desirable level for renal dialysis; iron 16 000 times above the human taste threshold, with lead, arsenic, copper, nickel and zinc levels also of serious concern.

This toxic mix is “brewed” in the Big Swamp and during significant rainfall events it is flushed into Boundary Creek. Water samples taken above the Big Swamp show the pH level to be slightly alkaline to slightly acidic range; at least 1000 times less acidic than the waters being flushed out of the Big Swamp. The presence of heavy metals in the waters above the Big Swamp is miniscule (see graph page 12).

Toxic Gases. (See page 56 CFA comment.)

The Big Swamp contains all of the ingredients and means to bring about chemical and bacterial reactions and microbial oxidations that can produce a range of toxic gases and dust. The three main sulfur gases emitted from wetlands are hydrogen sulfide, volatile organic sulfur compound gases and sulfur dioxide.

Any fire episode increases the mixture and types of gases that have the potential to affect and cause problems to human health. Gases carried in the winds of a fire can widen the area of influence from these gases many fold.

Unfortunately little is known about the gaseous components of the sulfur cycle in Australian inland wetlands. Initial work measuring ambient air in wetlands indicates that hydrogen sulfide may not be the main gas responsible for foul smells and that hydrogen sulfide may even be a minor component of a gas cocktail produced. The situation in the Big Swamp is made even more complex as it has been reported that the 2010 fire is also burning in layers of brown coal.

Most of the research has been conducted in saturated or periodically dried wetlands. The Big Swamp is remarkably different in that it has been slowly dried out, hasn't re-saturated and has had the added compounding influence of wild fire.

It is one thing to know exactly what the range of dusts, noxious and toxic gases that are produced in a saturated, drying, dry and burning peat wetlands and quite another to know how these individual and or mixtures of gases, affect human health. The answer to the first part of this statement is that there are a very limited number of laboratories in the world with the expertise to measure sulfur gas emissions from wetlands, let alone all of the other dust and gas possibilities.

In regard to the affect of these gases and dust on human health, one can only speculate. However, in October 2010 at a public meeting held in the Yeodene Hall to discuss the peat fire in the Big Swamp, members of the public voiced their concerns that the effects of the smoke had caused breathing problems with residents as far away as Birregurra. A doctor from Birregurra was in attendance and voiced a similar opinion. It was stated that the foul smelling smoke was evident for several months after the initial fire outbreak in March.

Recreational Pursuits & Safety.

The National Health & Medical Research Council (NHMRC) guidelines recommend that waters used for primary recreation should be in the pH range 6.5 – 8.5. The NHRMC recommendations for secondary recreation**(boating/Canoeing)** should be in the 5.0-9.0 range. Levels of 2.5 pH as recorded in the Big Swamp are exceedingly lower than these. Horseback riders, hikers, walkers, hunters, photographers, naturalists, campers and motorcyclists frequent this area on a regular basis. Tracks lead up to and pass close by the Big Swamp making access to the area quite easy.

Overlooking the burning Big Swamp one month after the initial outbreak.
CFA thermal imaging months later detected multiple hot spots underground.

Beside the highly acid water that looks perfectly fine to drink, there are the gases and ash dust to contend with. For the unwary, and considering that the peat has been reported to have been burning underground for 12 years, falling into an underground cavity or smouldering ash bed is a strong possibility.

An acid bath type trench dug 3 metres wide and 3 metres deep in an attempt to prevent the peat fire spreading downstream, is in itself an extreme safety hazard. The sides are vertical making escape from the trench extremely difficult.

The log in these two pictures is where the bed of Boundary Creek crosses the trench.

Fire.

It was reported in the Colac Herald 24 January 2011, that the CFA had informed residents back in October that the peat fire in the Big Swamp would continue to burn ***"for years to come."*** At this meeting it was stated that the fire was travelling 1 metre a day underground. Considering that this burning peat was the cause of wild fire in 1997, 1998 and 2010, the social impacts of a major outbreak on an extreme fire danger day would be horrific.

The following letter has been copied word for word and highlights how easy it is for the fire management of the Big Swamp to be overlooked due to a cool summer, fading memories of the catastrophes of Black Saturday and summer floods in Queensland and Victoria. Other priorities take over and a wild fire breaking out of the Big Swamp into the Otway Ranges is overlooked.

Note the date of the letter is in the middle of summer.

Colac Herald extract 7 January 2011. Headed "**Lack of action on peat fire**."

'***Now here's a thing! At the October 2010 Yeodene Peat Fire Meeting, the CFA said that a sprinkler system would be installed to contain the southern edge of the unsecured peat fire at Yeodene, that continues to burn underground in an area of seven hectares.***
The entire area would also be patrolled by the volunteers on high fire danger days, so the CFA informed members of the public who attended the meeting.
It is now January 2011, and nothing has been put in place.
There are no sprinklers and the access track to the area has been seriously undermined by CFA vehicles accessing it during the wet, to observe the situation.
One vehicle became totally bogged and now this track is no longer safe for any CFA vehicles, and under CFA ruling can no longer be used by manned CFA vehicles who may need to access the fire in order to carry out the directive which is that: volunteer brigades are responsible for local fire occurrences.
This is a total abrogation of responsibility from the top.
What does the CFA require of its volunteers?
That they are expected to run into a fire front on foot with no safe retreat?
Tonight at 8:15 pm I smelt swamp gas. The first of the season. This means that decomposition continues apace, that the peat is heating up and another outbreak is on the cards.
The peat throughout this district will be a problem for years to come.

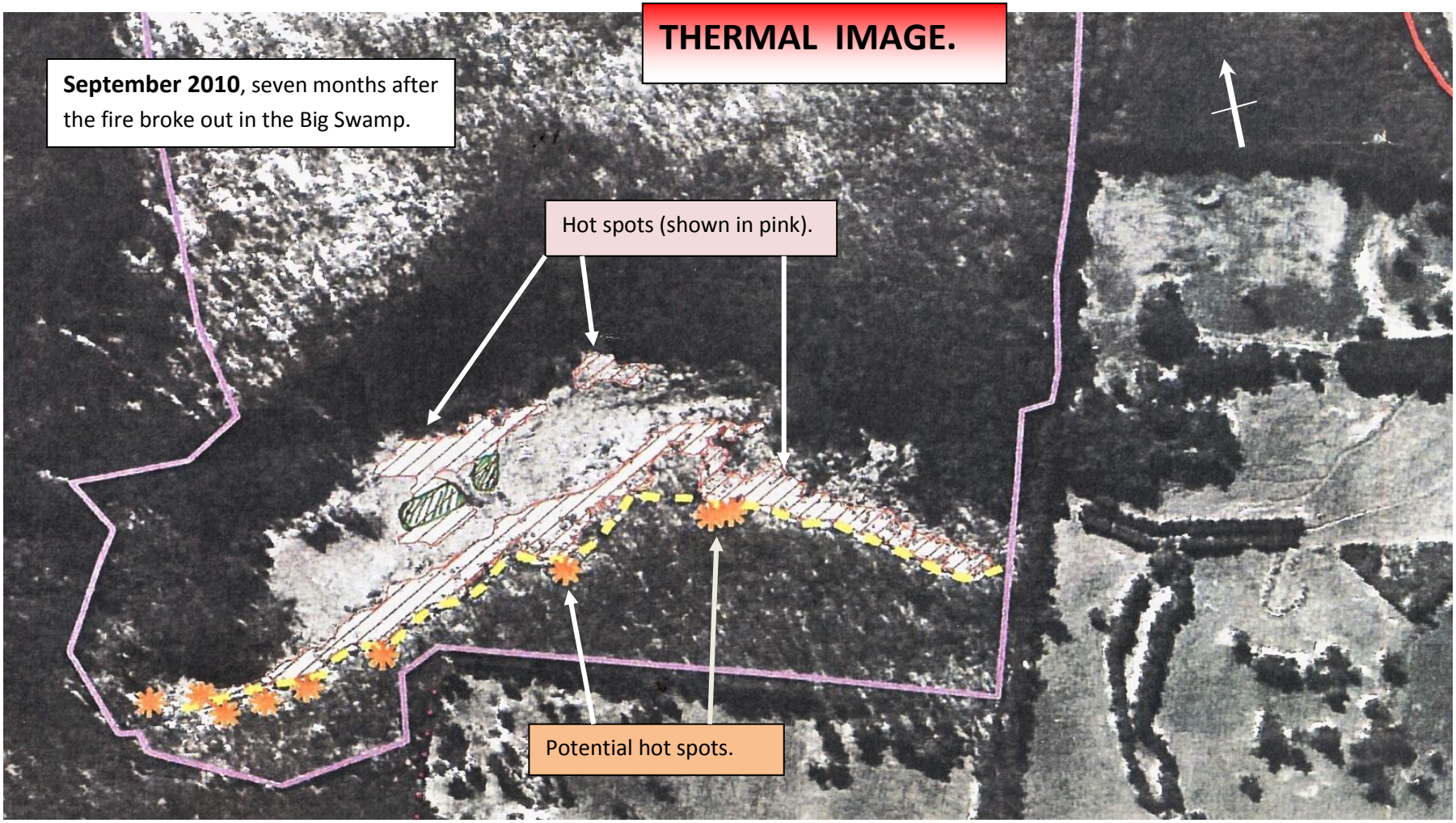
According to the CFA at the October meeting, 20 years or more.
So what is the CFA doing, at this precise moment in time?
I'll tell you what, nothing.
Happy New Year."

Victoria Moore,
Gerangamete.

The bed of Boundary Creek March 2010. 2 ML/day released upstream disappears into the Big Swamp before this location.

I was at the October meeting. I was also in the Big Swamp vicinity collecting stream data two days before this letter was published, and confirm everything Victoria has written. Usually walking into the area from the north I decided to enter the road reserve from the south along Swan's Access. The weather had improved and it was anticipated the track would have dried out. Further to Victoria's story, if the CFA needed quick access to the Big Swamp from this direction it would have been impossible. Four sizeable trees had to be chain sawed off the track. Along the southern edge of the swamp the track was overgrown with metre high grasses. Promises made to the local community have not been kept. Through luck, the summer of 2010-11 continued to be a mild one with frequent rainfall events.

It became known in June 2010 that aerial thermal images of the Big Swamp had been taken. A CFA officer denied that the CFA had copies but then paradoxically images were put on display at the October meeting in the Yeodene Hall. Repeated requests were then made to the CFA for copies of these images and eventually a reply denied access. A long drawn out process ensued to obtain copies. A Freedom Of Information request was submitted to the CFA, 3 December 2010, and finally copies were obtained in April 2011 at considerable expense and angst. A classic case of obfuscation.



See pages 52-54 for copies of the thermal images supplied by the Country Fire Authority (CFA). See page 11 for another aerial shot.

After a very wet summer of 2010-2011 and the fact that much of the Big Swamp was under water, one could easily believe that the threat from fire had long passed. However, history of the Big Swamp episodes tells us that looks can be deceiving.

Primary Contact & Recreation.

The Victorian State Government includes the term “Beneficial Uses” in a great many number of its documents. These references to Beneficial Uses and the accompanying statements are made in an effort to ensure the protection of existing and potential uses of areas such as the Big Swamp. One of these Beneficial Uses is Primary Contact and Recreation. Unfortunately the Beneficial Use of Primary Contact and Recreational use in regard to the “wilderness” area of the Big Swamp has been compromised beyond re-establishment in the foreseeable future. The “Healthy Park” section of the “Healthy Park, Healthy People” doctrine of Parks Victoria, no longer exists in the Big Swamp.

The multitude of benefits that flow from contact with nature have been well researched and include:

- positive effects on blood pressure, cholesterol and outlook on life,
- reduction of crime,
- fostering of psychological healing,
- reducing stress,
- boosting immunity,
- promoting and facilitating healing,
- enhancing productivity, improving concentration, and
- improving mental capacity.

The many people who have gained health and well being benefit from access to this unique part of the world no longer enjoy such benefits. A Beneficial Use, Primary Contact & Recreation, and the resulting positive health benefits no longer exist as this photograph shows.

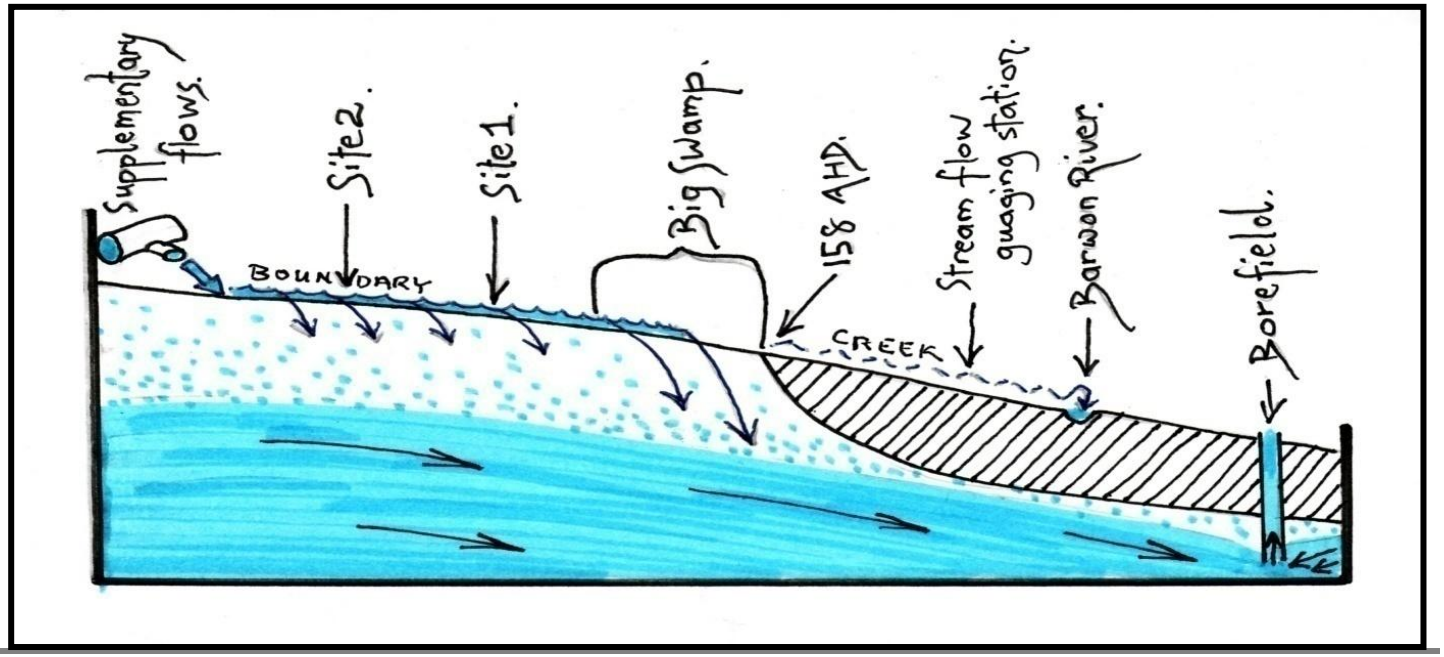
CHAPTER NINE

Groundwater Contamination.

A condition on the Licence to extract ground water from the Barwon Downs Borefield is supplementary stream flows have to be provided whenever a pre determined trigger level was reached **(158.5 metres AHD in the Yeo 40 observation bore).** Allowing the water table to drop below this level meant that Boundary Creek and consequently the Big Swamp would dry out. The water table has been dropped metres below this trigger level and supplementary flows have been released from the Cola Otway Pipeline for considerable lengths of time over several years. The diagram on this page and the graph on the next highlight the futility of this exercise because the supplementary water disappears from Boundary Creek as the stream bed passes through the Big Swamp area **(see pages 33 & 31 photographs – a dry Boundary Creek)**.

Diagram representative of the process. (Not to scale)

Supplementary flows are released from the Colac Otway Pipeline at point **D** page 5.



In periods of low rainfall events the supplementary water disappears in the vicinity of the Big Swamp.

This graph is taken from Barwon Water's 2008-09 report to Southern Rural Water.

This graph is almost a mirror image of the situation that has been happening for several years.

Trigger Level.

Water Table Level approx. 8 metres below trigger.

Supplementary Flows released (see point **D** page 5).

Zero Flow in Boundary Creek below the Big Swamp (see point **B** page11).

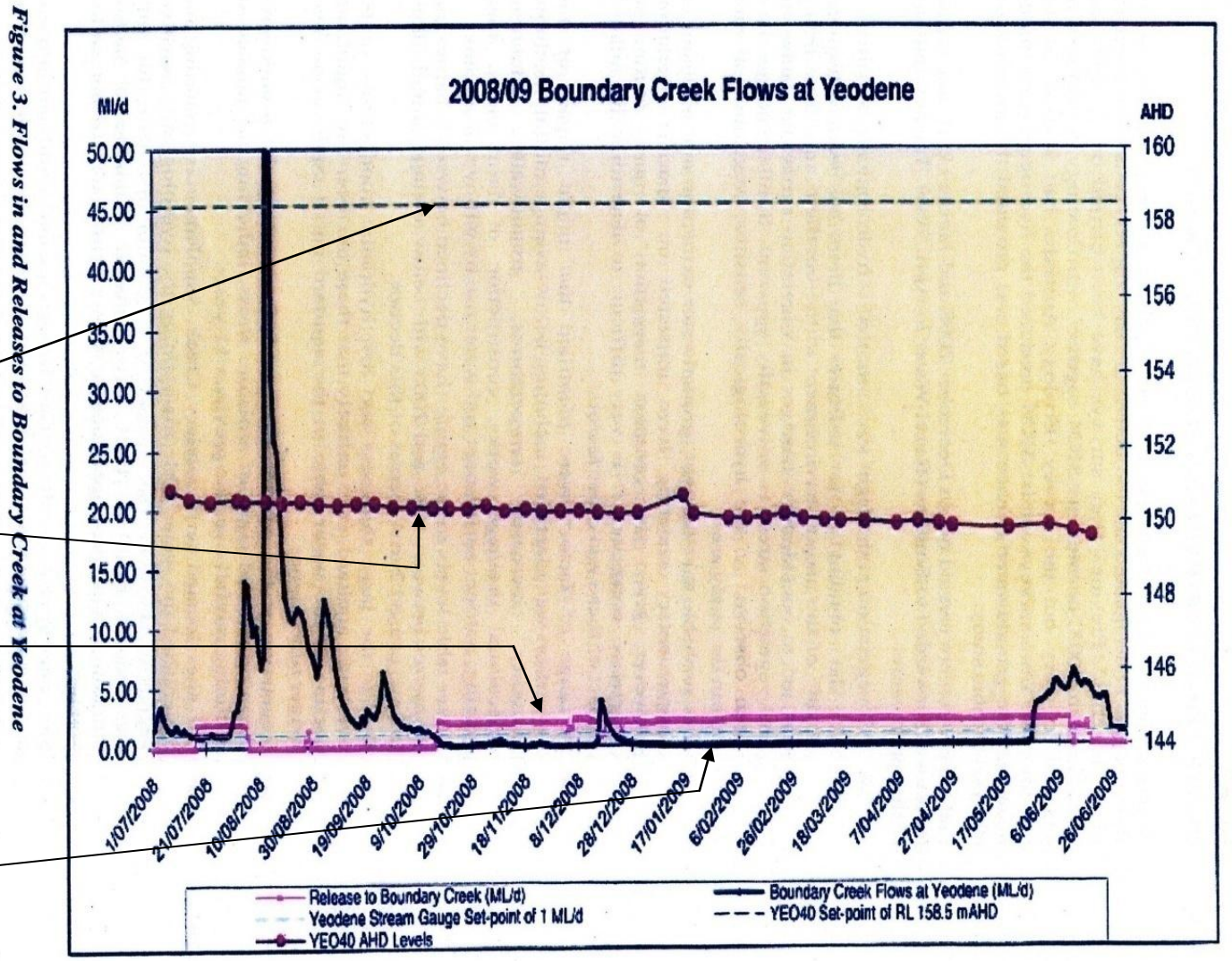
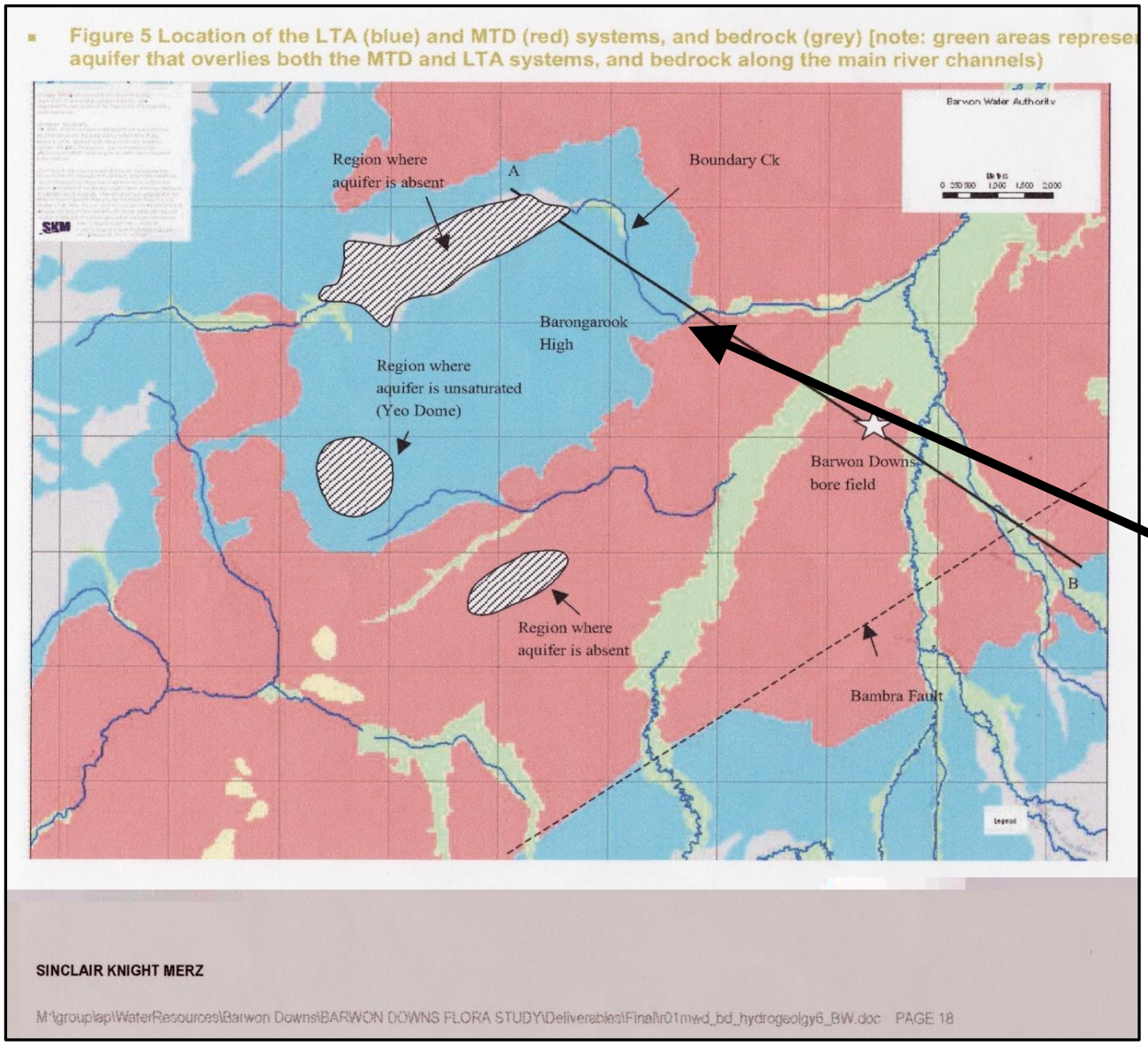


Figure 3. Flows in and Releases to Boundary Creek at Yeodene

- 15 -



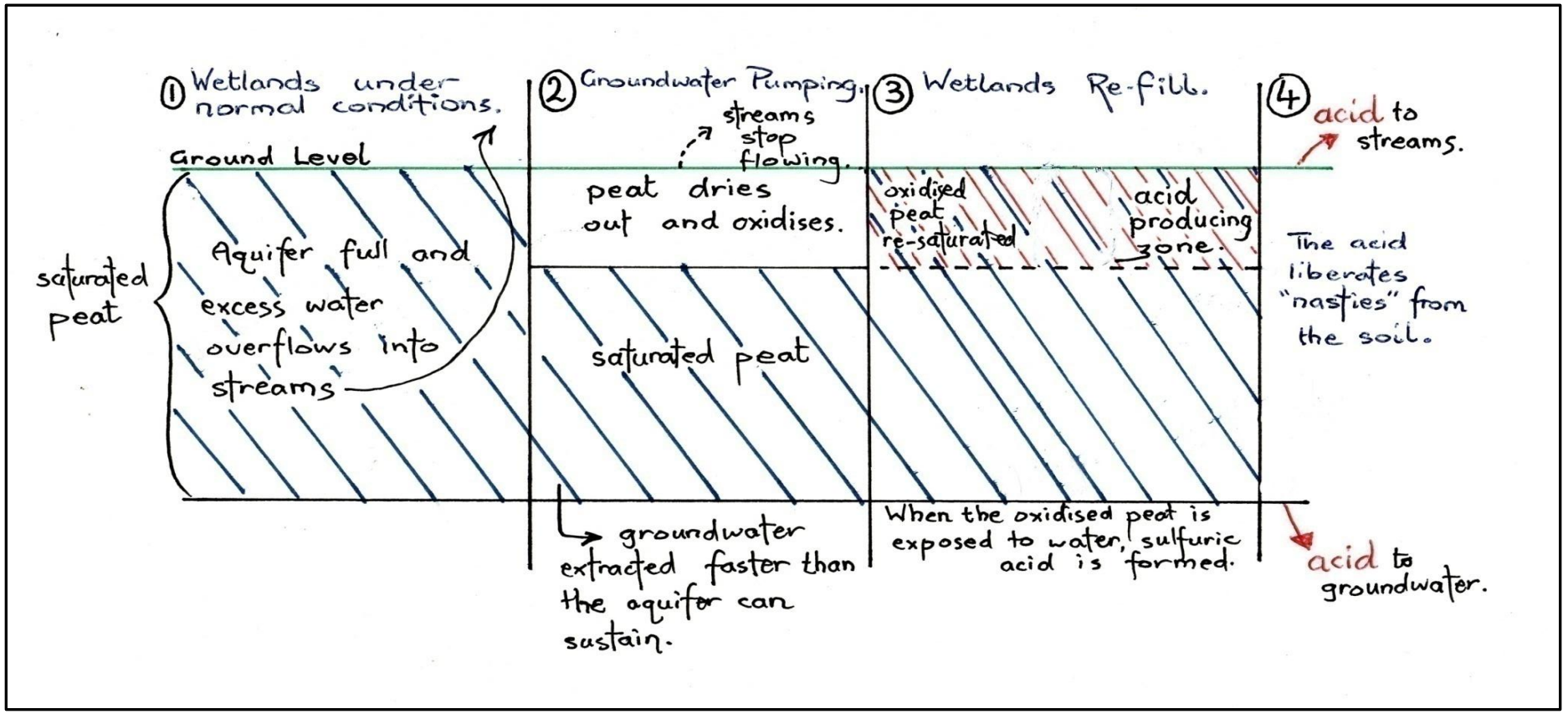
The Big Swamp is located where the aquifer outcrops at the surface as can be seen in this map. The blue indicates the outcropping aquifer that Barwon Water is pumping from at Barwon Downs.

The red area indicates the sediments that overlay the aquifer as its formation goes underground.

The Big Swamp.

When the aquifer is full, waters flow out of the aquifer (blue area) into springs, wetlands and streams.

The diagram below shows how a full aquifer overflows into Boundary Creek (1). When the peat dries out and oxidises the process of acid production starts (2). Rewetting the area with supplementary flows or from rainfall events creates the acid production cycle and the liberation of heavy metals and other pollutants is set in motion (3). The resulting toxic mix in the water can go two ways (4). If there is sufficient rainfall it will flow downstream in Boundary Creek. If there is not sufficient rainfall the acidified water and its contents will seep into the depleted aquifer. Groundwater contamination being the result.



CHAPTER TEN

The Ecosystems.

An ecosystem is a basic functional unit of nature comprising plants and animals and their nonliving environment of air, water, soil and rock, intimately linked by a variety of biological, chemical and physical processes. The living and non living interact with each other; they influence each other's properties and both are essential for the maintenance and development of the system. Groundwater in the Otway Ranges is one of these crucial factors and is involved in a multitude of biological, bacterial, microbial, chemical, physical and hydro-kinetic processes that interact with ecosystems above and below ground.

The ecosystems in and around the Big Swamp and along Boundary Creek, under the influence of a permanent groundwater source, had taken eons to develop to a relatively stable and resilient state pre groundwater extraction. The biological activity in the life cycles of the various species had adapted to a multitude of conditions peculiar to the Big Swamp locality, such as pH, seasonal variation, temperature, energy source, timing of events and a complex number of interacting variables that remained relatively stable from year to year.

However, the gradual removal of the permanent and reliable groundwater source from this natural balance, set in motion significant changes. The ecological checks and balances that had evolved in the Big Swamp came under serious threat. The water dependent flora and fauna species had to learn to adapt or be replaced by other species more akin to the changing environment and drier conditions.

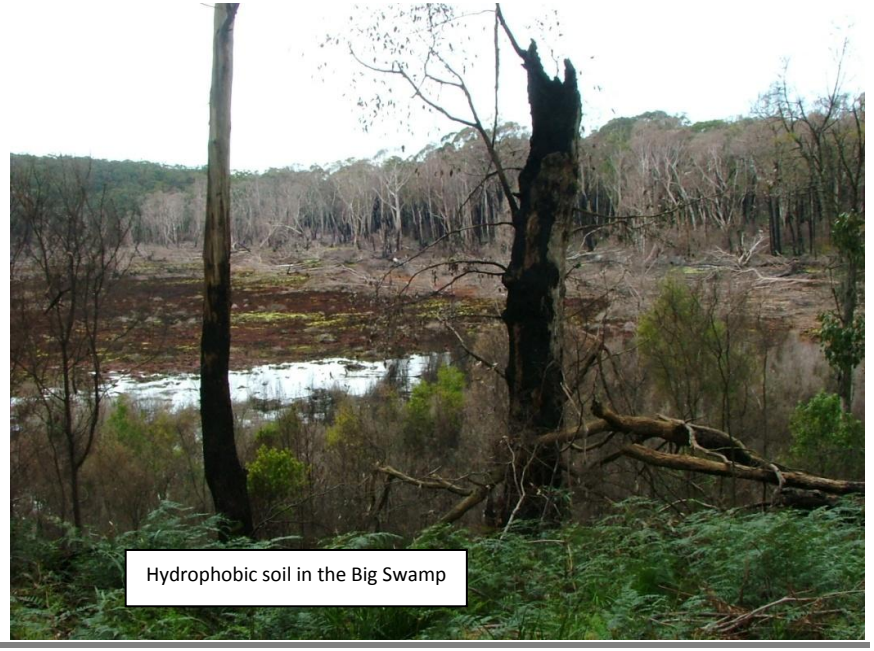
In time species tolerant to a drier environment would have taken place except for two significant factors;

- the presence of Acid Sulfate Soils, and
- soils with a limited ability to neutralise any acid produced .

Whenever the dry peat area experienced wet conditions sulphuric acid levels skyrocketed. Then the acid began to liberate previously locked up heavy metals. Besides the swamp drying out, the production of acid places the ecological checks and balances that had evolved in the Big Swamp under an even more sinister threat with soil health deteriorating. The chances of different species moving into the drier environment had little to no chance of establishment under such adverse conditions. The flora and fauna of the area could no longer survive as it had for eons and other species had little chance of colonising the area. To make matters worse the advent of fire compounded the woes of life in the Big Swamp. Fundamental conditions underpinning a healthy environment disappeared.

Soil Biology.

Understanding soil biology is still in its infancy stages. However, it is known that there can be at least 100 000 species with 10 million different individuals, in 1 gram of soil. There are bacteria, protozoa, fungi, nematodes, collembola, acari, isoptera and oligochaeta. These individuals crunch, much, decompose, transport and chemically degrade matter, provide a food source for those predatory animals with other specific roles, excrete enzymes, alter physical structures including the prevention of hydrophobia and influence rates of nutrient and energy flow.



Hydrophobic soil in the Big Swamp

All of these animals are soil processers decomposing plant residues, regulating plant nutrient supply, improving soil structure, binding soil together, regulating water quality and capturing and releasing greenhouse gasses. These soil life forms are vital in the maintenance of a healthy natural system.
Oxidising Acid Sulfate Soils changes all of these processes dramatically.

Symbiotic Fungi.

Although there is still much to learn and understand about the processes and functioning of soil biology some of the relationship between fungi and plants is fairly well known. Mycorrhizal fungi form a special bond with the rootlets of trees and other plants enabling them to take up water, nutrients and trace elements. In return the plant provides a food source for the fungi. The mycorrhizal fungus that attaches itself to the plant roots sends out hyphae or minute branches into the soil collecting and gathering. A handful of soil could contain kilometres of hyphae. These mycorrhizal fungi also provide protection for the host plants against attack by pathogens and invertebrates.

This symbiotic relationship is absolutely essential for the healthy growth and survival of the plants. The particular fungi that evolved in the Big Swamp cannot survive in the dramatically changed conditions brought about as the wetlands have dried out and re-wetted. The environmental conditions have undergone such a severe change that the soil biology has been unable to adapt. Mycorrhizal fungi die, inhibiting the ability of plants to take up water, nutrients and trace elements. Without the mutualistic association of fungi the vegetation becomes stressed, withers and dies.

Heavy Metals.

If the decimation of the mycorrhizal fungi does not kill the vegetation then the liberation of heavy metals into the soil most surely would, with soluble aluminium, manganese and iron reaching toxic levels. Aluminium toxicity limits plant growth; the plants become more susceptible to drought; the outer boundaries of root cells are attacked; the uptake, transport and use of several essential elements are reduced; the uptake of other elements can be increased and morphological damage to plant parts and the reduction of plant respiratory and protein synthesis occurs.

Considering that there is still so much to learn and understand about soil biology it can be assumed that the interactions and processes that are taking place are far more intricate and complex than depicted in the above mentioned words. The biological footprint in the Big Swamp has been drastically and dramatically altered and no longer exists as it did pre-groundwater extraction.

Hydrophobic Soil.

Hydrophobic soils are soils that repel moisture. This can come about by organic residues coating the soil particles. If the micro-organisms that break down the waxy, oily coating that gathers on the individual grains of soil are affected by acid and other toxins they can no longer present in sufficient numbers to prevent the soil from becoming hydrophobic. Fire can also create hydrophobic soils when this organic material is burnt and soaks into empty pore spaces in the soil.

Hydrophobic soil makes germination of seeds extremely difficult.

Droplets of water sitting on hydrophobic soil.

SOURCE:(http://www.agcsa.com.au/static/atm_articles/html/4_6b.html)

This photograph was taken in 2009, eleven years after the 1998 fire. (Page 27 also shows a picture in this same vicinity.)

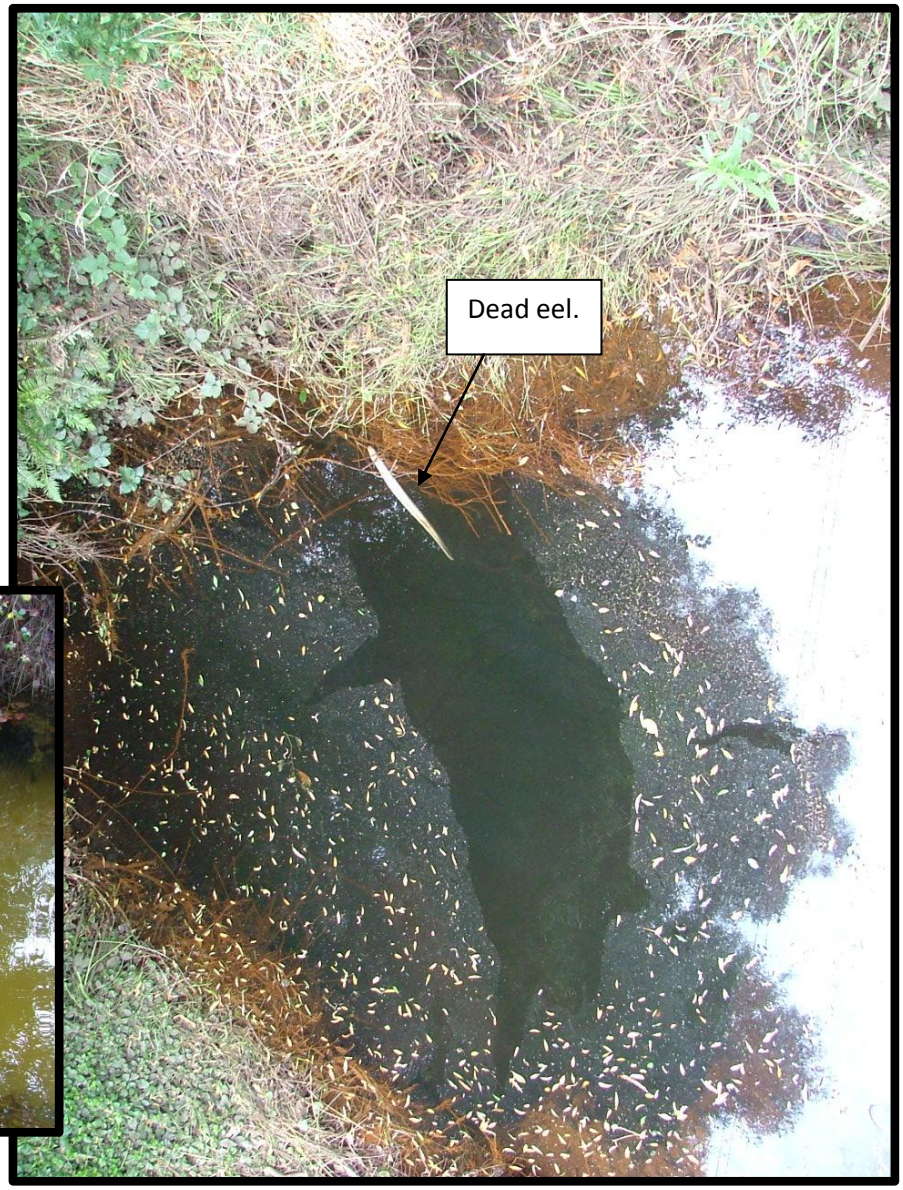
There has been no vegetation re-colonisation of this area and it is most likely since the re-burning of this same peat in 2010, that there will not be in the foreseeable future. Bracken fern has been the only plant having a modicum of success to survive.

In stream Animal Life.

The Dilwyn and Pebble Point Aquifers used to release on average 3.2 ML/day during the summer months providing Boundary Creek with a permanent water supply. The majority of this water flowed out of the Big Swamp. As a result Boundary Creek was a thriving and vibrant groundwater dependent ecosystem with abundant life forms active in its waters. Animals high in the food chain included platypus, blackfish, freshwater crayfish and trout. However, with Boundary Creek drying out for extended periods, over 1000 days since 1984, many of these life forms have not been able to exist.

Even if there was a chance of re-colonising the stream and wetlands from downstream habitats not affected from the drying out, the acid and heavy metals levels and periodic deoxygenation of the waters would make this impossible. The life forms that had evolved in this part of the world had not adapted to pH levels below 4 or tolerances to the concentrations of heavy metals.

The only life form I have observed in Boundary Creek between the Big Swamp and the West Branch of the Barwon River in the last 4 years has been one dead eel. This photograph was taken 25 January 2011. The eel was approximately 60 cm long. A very interesting observation was made when downloading the picture of this dead eel. The scum on the surface of Boundary Creek around this eel had separated taking leaf matter with it. The water surface around the eel was scum free.



Another interesting fact observed when taking the photograph was the colour of the pool over which the eel floated. In the depths under the crystal clear surface water it was almost a black water. During past visits this deep pool of water was usually a light greeny/yellow cloudy colour.

Flocculent Deposits.

In stream life forms lower down the food chain rely on a healthy watered stream bed to carry out their various biological functions. Lack of water, food sources, places of refuge and temperatures changes would disrupt their life cycles. Beside the acidic and heavy metal levels, the iron oxyhydroxides and hydroxide flocculants deposited and coated on the stream beds and banks would ensure that these lower order communities could not easily survive.

Pebbles, sticks and stream bed covered with a thick floc.
The inserted dark stick shows the difference.

Stygofauna.

Stygofauna are those animals that remain underground in aquifers for their complete life cycles (stygobites); animals that inhabit the groundwater by chance (stygoxenes) and animals that inhabit groundwater on a permanent or a temporary basis (stygophiles). Groundwater ecosystems are dynamic systems comparable in complexity to surface ecosystems and contain a highly diverse fauna. This subterranean fauna can be found at surprisingly great depths and contains a wide diversity of animals; amphipods, isopods, copepods, ostracods, bathynellaceans, gastropods, water mites, insects, fish and microbial communities.

Stygofauna have numerous potential functional roles in the groundwater systems. Some of these roles include the maintenance of voids; enhancing the release of organic carbon; the cycling of nutrients; promotion of biofilm activity; improved hydraulic flow paths; the provision of favourable sites for microbial activity; movement and mass transfer of energy and materials through the sediments.

Unfortunately there have been no studies done on stygofauna in the aquifers connected to the Big Swamp but considering that Australia contains a stygofauna of global significance there can be no doubt that species do exist in the subterranean waters of the Otway Ranges.

Just as the drying out of the Big Swamp due to the lowering of the groundwater table levels has brought about catastrophic impacts on the above ground ecosystems the same can be assumed for the subterranean ecosystems. Water dependent species cannot survive in a dewatered situation and the acid and heavy metal toxins that are generated on the surface and then leach into the aquifer would be as lethal to stygofauna as it is to the terrestrial species.

CHAPTER ELEVEN

The Statutory Authorities' Inertia.

One of the most disturbing impacts resulting from the drying out of the Big Swamp has been the manner in which the hierarchy of the Environment Protection Authority, the Department of Sustainability & Environment, the Department of Primary Industries, Barwon Water, Southern Rural Water, the Colac Otway Shire and the Corangamite Catchment Management Authority have responded to this calamity.

The response of these authorities can best be summed up when referring to the terms "inert" and "inertia" as found in The Concise, The Thesaurus, An A-Z Dictionary of Synonyms, 1996 Geddes & Grosset Ltd:

INERT
inactive, lifeless, passive, apathetic, comatose, dronish, idle, torpid.

INERTIA
apathy, sluggishness, passiveness.

Referring to the Oxford Pocket Dictionary places a slightly different emphasis on these definitions but none the less disturbing:

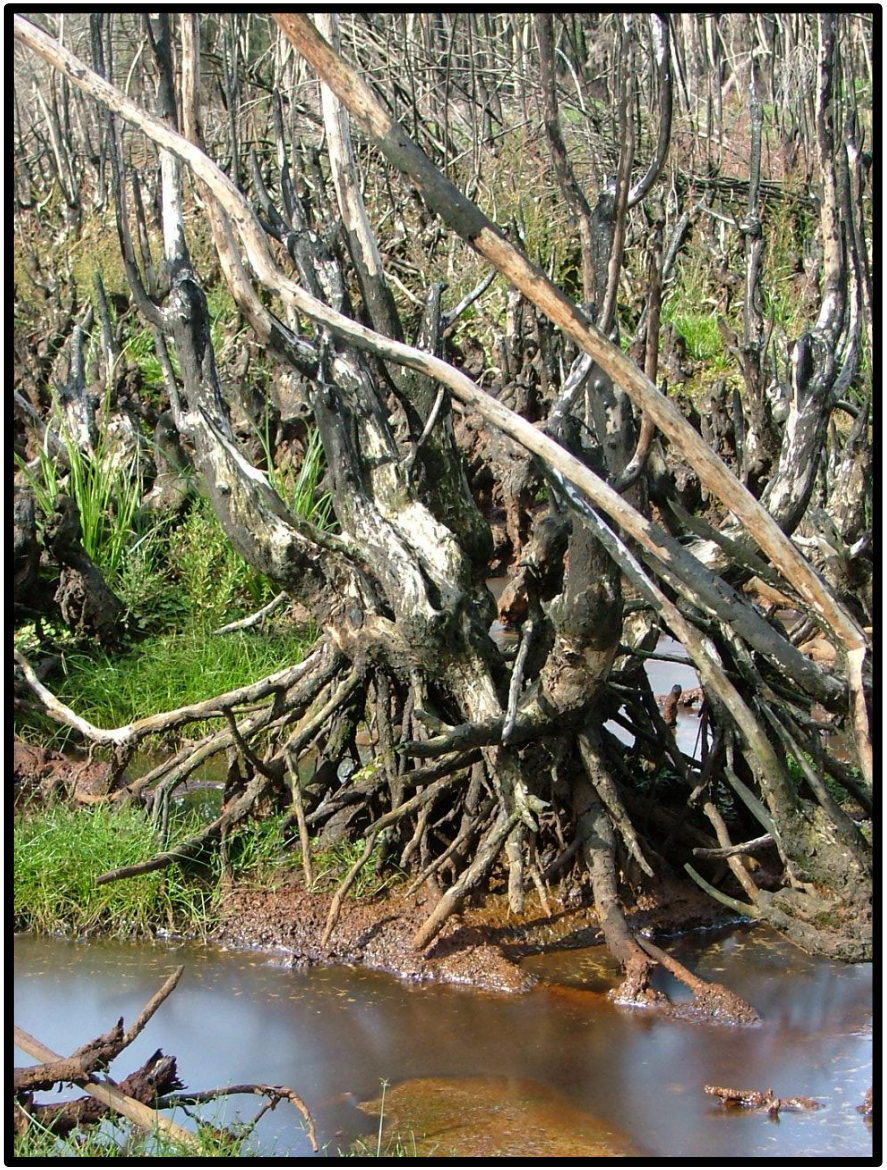
INERT
Without inherent power of action, motion or resistance; sluggish, slow.

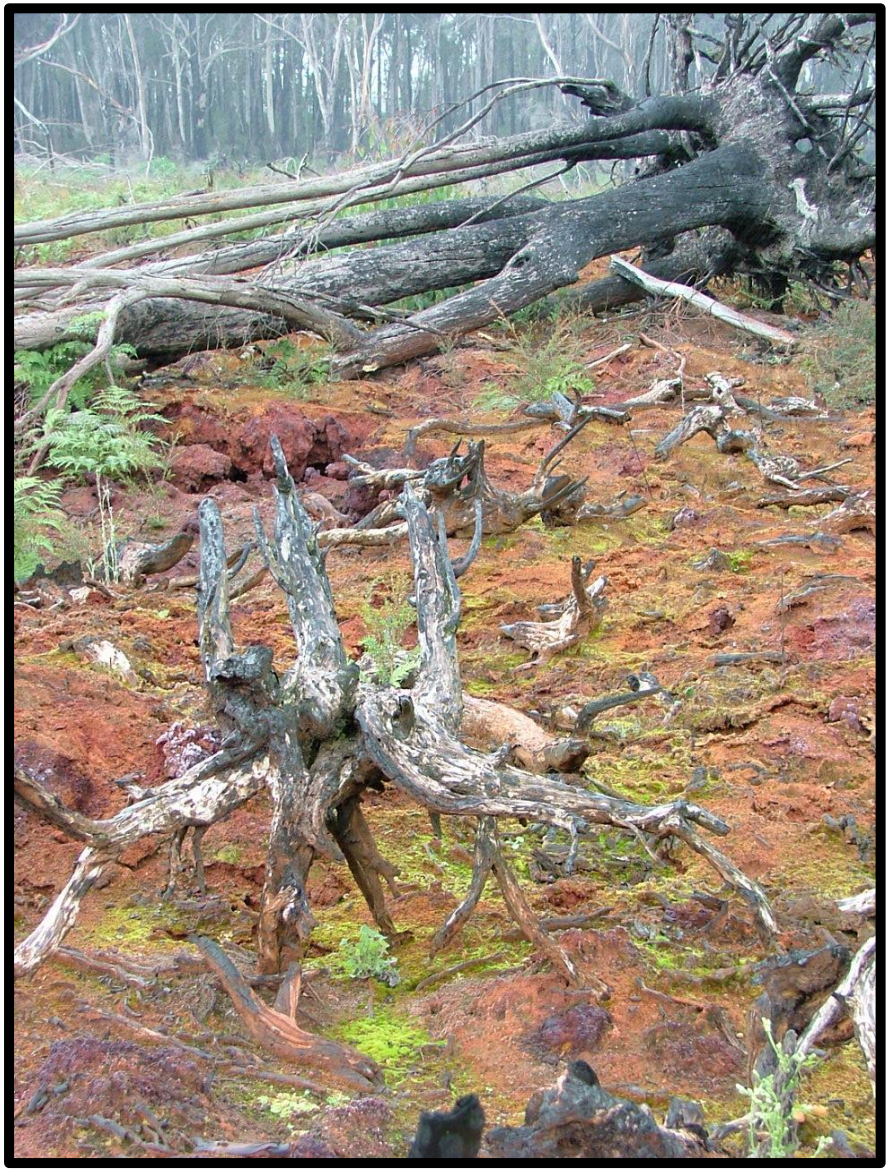
INERTIA
Property by which matter continues in its existing state of rest or uniform motion in a straight line unless that state is changed by an external force.

CONCLUSION

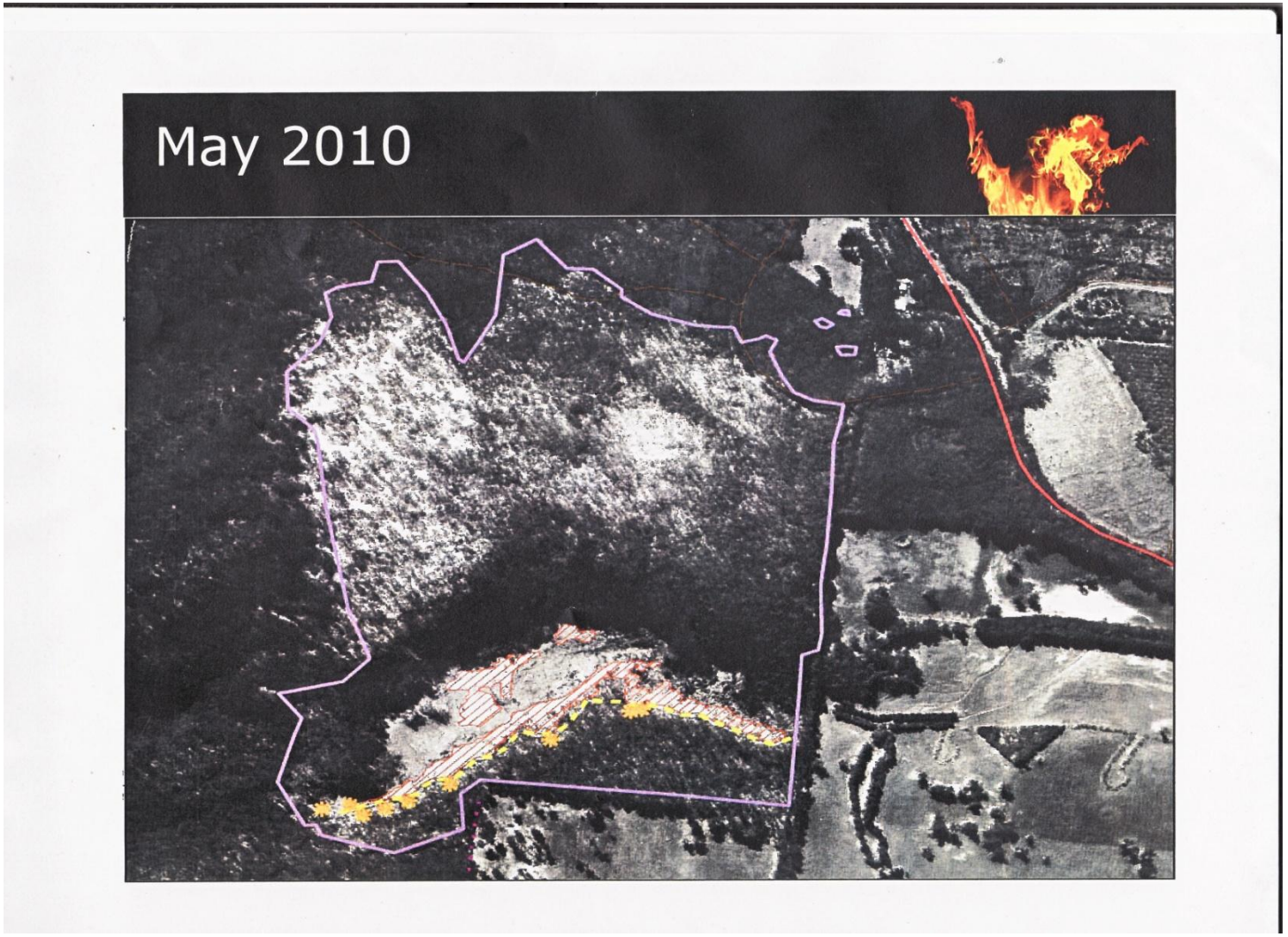
Many of the detrimental impacts that have taken place along Boundary Creek were first muted in a study going back as far as 1986.[56] This study has largely been ignored and unfortunately many of the recommendations made over two decades ago still haven't been implemented.

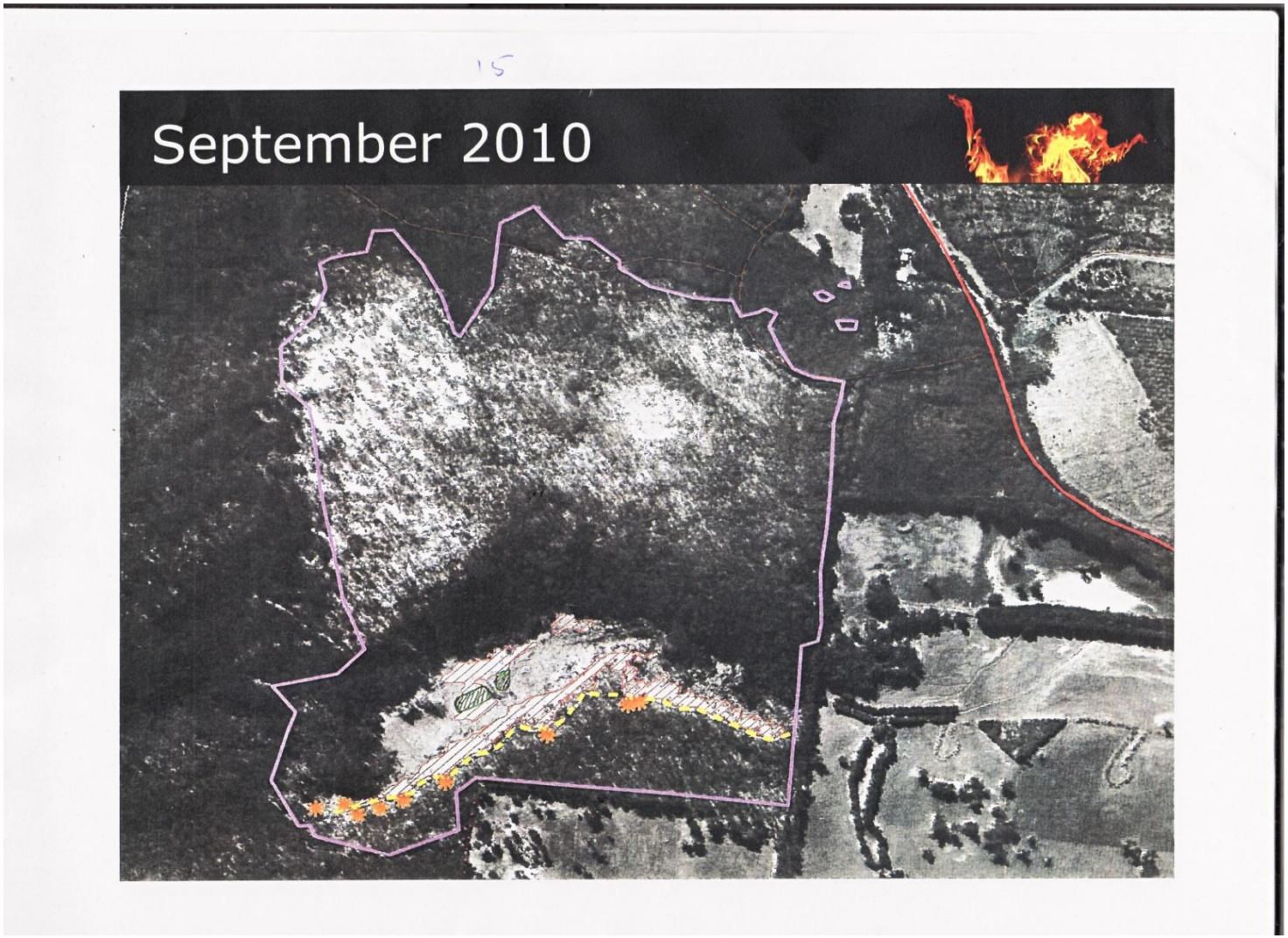
The impacts on the Big Swamp will continue and the area of impact will increase until Government Authorities shake off their inertia. The cause(s) of the Big Swamp issue; the development and implement of an appropriate management plan, need to be immediately addressed. Considering that the earliest symptoms of a serious problem in the Big Swamp, Boundary Creek area were evident as far back as 1993, there seems little hope that the above named authorities will do any more than huff and puff like they have in the past.





Appendix One

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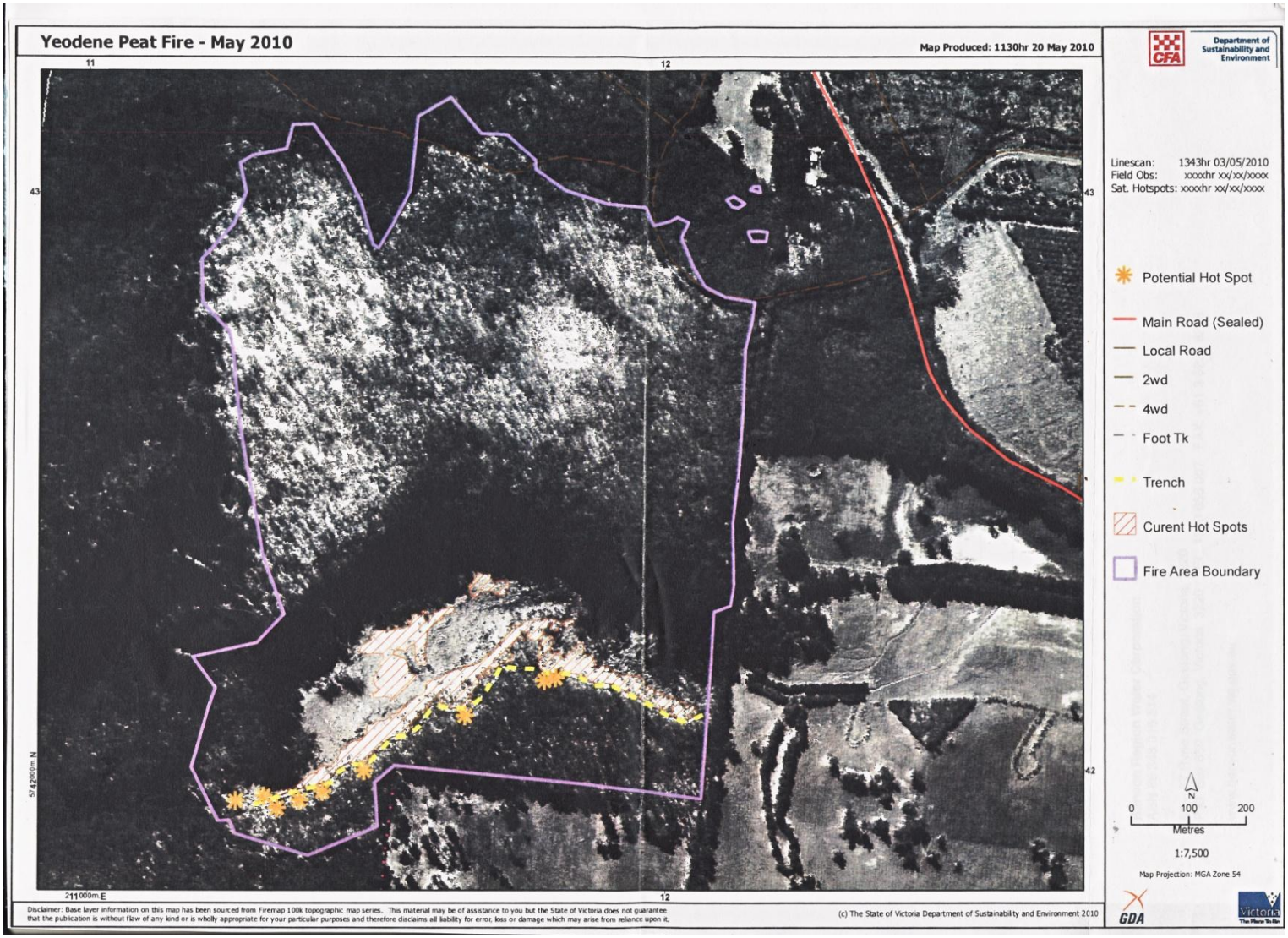
September 2010


Yeodene Peat Fire - May 2010
Map Produced: 1130hr 20 May 2010
CFA
Department of Sustainability and Environment
11
12
43
42
5742000m N
211000m E
Linescan: 1343hr 03/05/2010
Field Obs: xxxxhr xx/xx/xxxx
Sat. Hotspots: xxxxhr xx/xx/xxxx
Potential Hot Spot
Main Road (Sealed)
Local Road
2wd
4wd
Foot Tk
Trench
Curent Hot Spots
Fire Area Boundary
N
0
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200
Metres
1:7,500
Map Projection: MGA Zone 54
GDA
Victoria
Disclaimer: Base layer information on this map has been sourced from Firemap 100k topographic map series. This material may be of assistance to you but the State of Victoria does not guarantee that the publication is without flaw of any kind or is wholly appropriate for your particular purposes and therefore disclaims all liability for error, loss or damage which may arise from reliance upon it.
(c) The State of Victoria Department of Sustainability and Environment 2010

CFA Comment.

This extract has been taken from the Country Fire Authority "Yeodene Peat Swamp Fire History Risk Mitigation Plan Discussion Paper April 2010."

"3.2 Ongoing health effects due to smoke emissions.
A considerable amount of smoke has been given off and will continue into the atmosphere. This is accompanied by very strong odour that is quite permeating to the surrounds including humans, animals and infrastructure for potentially quite a distance in every direction from the site.
Reports of smoke impact from Birregurra, Yeodene Township, Forrest, Barwon Downs, Colac and Barongarook have been received, with locals in the immediate vicinity receiving almost daily impact fgrom smoke.
The long term health issue due to exposure to this smoke pose a risk to members of the public and should be noted."

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