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SUBMISSION TO THE S.A. MURRAY DARLING BASIN ROYAL COMMISSION

For the most, details within this Submission were Investigated by the undersigned over a period of 17 years, from extensive interviews, presentations, Forum's, and from my position as Executive Producer for the documentary ***Muddied Waters*** in 2012.

Generally, my work exclusively deals in matters of Marine & Aquatic Ecology. I'm closely associated with basin irrigators and growers, river councils and the scientific community; in particular with Federation University and Professor Peter Gell from St Helens, near Ballarat in Victoria. Prof Gell is internationally recognised for his introduction of diatom research into Australia, including that done in South Australia's Lower Lakes and Coorong.

I also share and exchange my findings with the that of Scientist Ian Rowan BSc Hon who, until recent weeks also lived in SA, adjacent to the Lower Lakes, the Coorong and the Murray Mouth. A sample of his research concerning volumes of salt being exhausted through the Murray Mouth is attached.

I bring to your attention an attached document by Professor Gell: ***"Watching the tide roll away - advocacy and the obfuscation of evidence,"*** Published by CSIRO Publishing on 4th March 2018. Prof Gell in a recent discussion requested assistance with the inclusion of his above document within this Submission. The undersigned agreed to do so due to this same document being an essential part within my Submission data to this SA Royal Commission.

I note with interest, your *"Issues Paper*," the purpose of this paper, the overview and the terms of reference brief, commencing on page 5., and in particular item 27 on page 6 where the Commission welcomes the opportunity to speak to people outside the main cities concerning experience - good or bad – of the Basin Plan, and to hear their insights in relation to it.

- Of particular interest from my perspective are the dot points commencing at the head of the page -6-. In particular the second and third dot points: "Whether the Basin Plan in its current or amended form is likely to achieve the objects, purposes and desired outcomes of the Water Act and Basin Plan," and

- Whether the Basin Plan is likely to achieve the enhanced environmental objectives and the recovery of 450GL of water through efficiency measures?

I Note with particular interest PAGE 7 subheading "**AREAS OF PARTICULAR FOCUS**" and item 28 "*In the course of its reading and information gathering processes to date*, and also item a) below- *Process used to determine the Environmentally Sustainable Level of Take".*

With great respect to the SA Royal Commission, it is here where we also focus.

I may now be talking in a plural sense given I occasionally share a good deal of my work with a local Scientist, Ian Rowan BSc with Hons.

From our perspective, it's not so much about SDL's as these are argued upstream with our support. **Nonetheless, we're acutely aware of the damaging results of over-bank flooding.**

The cost to farmers alone during the late 2015/early 2016 period was individually in the half million-dollar range, with several having their crops and fencing completely destroyed. A year's work wasted with a huge damage bill for many! Photographic evidence shown to Federal Assistant Water Minister, Anne Ruston at a meeting in Yea in Victoria following that questionable flood, became the catalyst for a lively restaurant meeting in Adelaide between Basin Water Ministers. The subject made headlines across the basin. Your writer personally attended the meeting in Yea.

From our perspective, it's all about truth behind the spreadability of volumes of precious water and its value adding across the basin. Its also about climate change and monsoonal activity, causing reduced rainfall over the catchments leading to reduced run-off into the storages, and **an un-willingness by the authority to really listen and learn that its wider environmental push is destroying the basin.**

This notion is shared across our wider food bowl!

In essence, water availability into the basin is waning due to recently realised climatic differences; with poor storage availability to cater for rare flood events and overbank flooding that has already created further, enormous difficulties for scientists, for growers, councils and residents across the basin.

Scientists including Professor Gell from Federation University have recently described their findings with sediments discovered in the upper water columns across all basin rivers and the Coorong in SA. These finely granulated sediments are becoming suspended in the upper water column, entrapping sunlight so that it doesn't reach riverbeds and aquatic plant life, to a point where aquatic vegetation in some areas is no longer known. In turn, this affects the fish life longevity and that of other biota known to rely on aquatic vegetation within the basin river system.

There're major concerns with extensive and costly evaporation and seepage; particularly from the Lower Lakes. Poor consultation and decision-making processes prevail when it comes to equitable disbursal of our most precious resource.

From a geographical perspective, much of our championed work encompasses the delta end of the system, with a heavy emphasis on the Lower Lakes, the Coorong &

Murray Mouth and any progress with the SE drainage work. Nonetheless, we're certainly interested in the whole basin with an emphasis on rainfall precipitation reaching the catchments, Australia's food security, and the affects that growers endure daily through reduced SDL's. My contact base across the basin is therefore extensive by necessity.

We're well known by the MDBA! We do not always agree as shown when the MDBA Chair visited Goolwa some years ago to tell us "we're a thorn in the authorities side. We do correct its work on occasions! An example is attached, concerning basin salt levels exhausted out of the Murray Mouth by Goolwa Scientist Ian Rowan BSc Hon..

Of interest: due to our monitoring of the MDBA's fortnightly ***Whole of Basin Storages***. As at 02 May 2018, the Whole of Basin storages contain only 10,793GL out of a possible 22,256GL.

In support of the above, I have attached six documents of interest.

A Better Way for the MDB by Ken Jury is a 15-page chronicle detailing a widely accepted **Solution** for the Murray Darling Basin. Based upon known remnants of the Millennium Drought, with what remained across the basin – and what may be of use at the time, and to turn the drought aftermath around. This document is widely appreciated across the basin. In the past, former Federal Senator, John Madigan from Ballarat, personally delivered a copy to the then Prime Minister. Future drought is expected. It's a matter of when?

The paper, "***Future demands Barrages must remain in place***," by Ken Jury, is a paper prepared in 2016 as a result of Federal Senate Committee recommendations. In its committee recommendations and its Executive Summary, the committee considers the implementation of the Plan while requiring greater effort to minimize its negative impacts.

Overbank run-off – Its a river killer by Ken Jury is a recent paper (April2018) dealing with the destructive practice of overbank flooding and its damaging outcomes.

Two Million Tonnes Of Salt – A River Myth - By Scientist Colleague, Ian Rowan BSc Hon, is a culmination of serious investigations by the author over several years. Ian was able to secure calculative modelling data from the SA Department of Environment & Water (DEW) and the MDBA to enable the completion of his study. Of Note: The Chair of the MDBA, Neil Andrews recently conceded his 2 Million tonnes/yr figures were wrong. Chairman Andrews has lowered the 2 million tonnes figure to One Million tonnes with media in recent times. Nevertheless, as shown in the attached calculations, his figures need to be reduced further.

Watching the tide roll away – advocacy and the obfuscation of evidence, by Federation University's Professor Peter Gell, is prepared as result of an "*act of intellect suppression by scientists succumbing to the temptation of advocacy for environmental flows."* Details within the Abstract alone, reveal *"diminished credibility in the science behind the Basin Plan and acted to fuel discontent in those affected by*

water allocations." Prof Gell said. South Australia's **Lower Lakes and Coorong** feature heavily in this vital paper, recently published by ***CSIRO Publishing*!**

Truth: Revealing Science behind the Lower Lakes – A message to the South Australian Government! Your Lower Lakes were not always fresh," was researched and written by Senior Investigative Journalist, Ken Jury after learning and investigating how a SA Government Department under the former Labor Government may have allegedly been involved in a questionable, departmentally commissioned science paper (remaining online today), concerning the history of Lower Lakes and the Coorong. In question at the time, prior to the development of Professor Peter Gell's paper, "***Watching the tide roll away – advocacy and the obfuscation of evidence,"*** where the value differences within the document in question:
AN ENVIRONMENTAL HISTORY OF THE LOWER LAKES AND THE COORONG, to those as described in the original scientific findings paper, ***Palaeolimnological Evidence for the Independent evolution of neighbouring terminal lakes, the Murray Darling Basin, Australia, 2007,*** following the necessary field research work and core sampling findings at the time.

Footnote: the question of whether the Lower Lakes in pre-barrage times, were always fresh, as several government agency literature suggests; the subject continues to be a moot point across all basin states, when arguing the loss of billion of dollars worth of freshwater to the Lower Lakes.

Yours faithfully,

Ken Jury

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Marine & Aquatic Ecology
South Australia

May 10th 2018.

TWO MILLION TONNES OF SALT – A RIVER MYTH

In the MDBA "Plan" and many associated reports it is often stated that, in order to keep the Lower Lakes "fresh", 2 million tonnes of salt per year must be flushed out through the Mouth. No justification for this value has ever been given and even the MDBA's own modelling shows this value is an over exaggeration. Yet it is still included as a fact and often used as a catchcry for those incapable or unwilling to do their own calculations including governments.

Since 2010 more data have become available and it is now possible to compare more accurately the relationship between Lake salinities and estimated Barrage outflows. The main points are summarised below and in the accompanying graphs and table:

-During the Millennium Drought salinities in Lake Alexandrina rose to 6000 EC.

-The flood of 2010/11 where daily flows reached 70+ GL quickly reduced those Lake salinities to 500 EC within about 6 months.

-During the 11/12 and 12/13 water years flows were still moderately high at an average of 7,000 GL/y and the salinity remained at about 500 EC with an estimated average annual salt export of 1.8 tonnes.

-During the 13/14 to 15/16 water years flows were very low (1,800 to 700 GL/y) and estimated average annual salt export was only 0.5 million tonnes. Lake salinity gradually rose to 900 EC over this 3 year period but was still below the 1000 EC MDBA Plan threshold.

-In 16/17 flows once again increased and salinities quickly fell again to less than 500 EC.

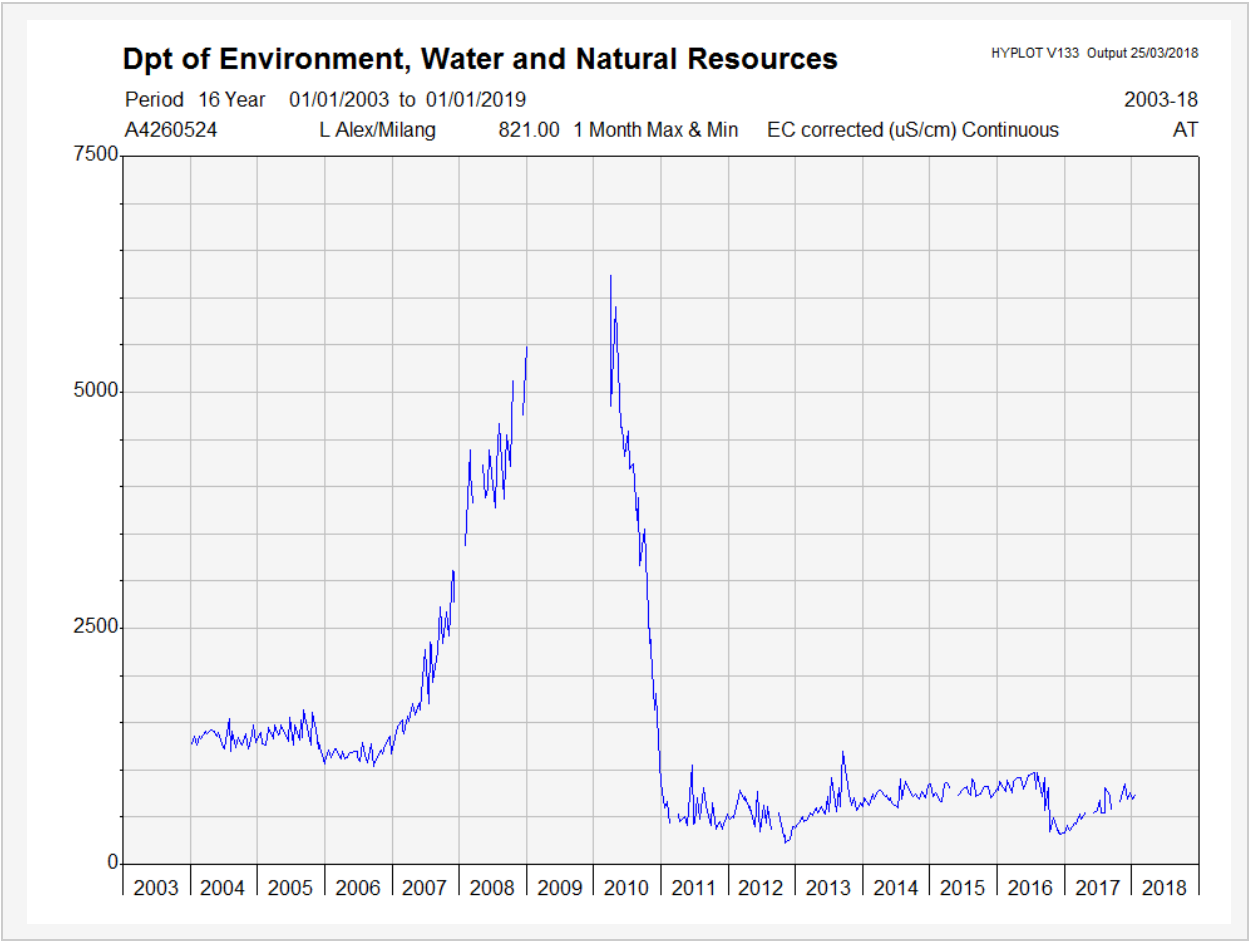
-And over the 7 years from 11/12 to 17/18 annual salt export has only averaged 1.05 million tonnes.

The conclusion must therefore be that the 2 million tonnes of salt export catchcry is a myth (although included as Law in The Plan) and that even with low flows and a salt export only about 0.5 million tonnes/y, salinities will remain within acceptable limits for many years. The greater the flow then the lower Lake salinity will be.

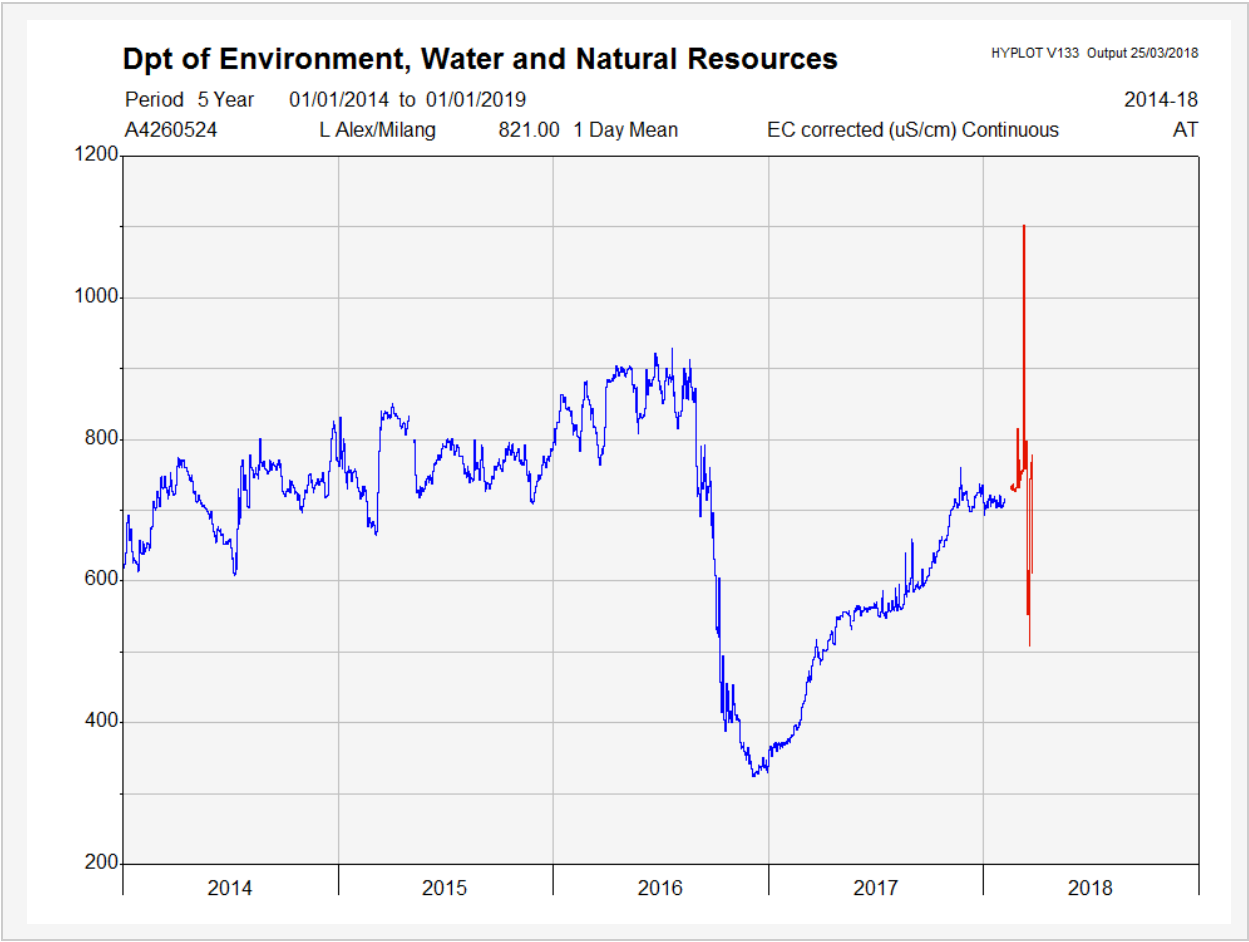
This means that, in order to keep Lake salinities below 1000 EC, the required flow is much less than those modelled in "The Plan" (median 3000 and average 5000 GL/y). These lower flows will require the Mouth to be kept open by dredging as we have been doing for the majority of the time since 2002 but by adopting this strategy much fresh water can be saved for more productive purposes rather than used for scouring the Mouth and being lost out to sea.

Ian Rowan, BSc Hons,

May,2018



Water Year	Barrage Flow GLx1000 (est)	EC Av at Milang	Annual Salt export Million tonnes	
10-11	12.7	1395	5.1	MDBA
11-12	8.8	434	2.2	MDBA
12-13	5.3	460	1.4	MDBA
13-14	1.78	676	0.7	MDBA
14-15	1.2	722	0.5	MDBA
15-16	0.66	800	0.29	MDBA
16-17	7.0	490	1.84	MDBA
17-18	1.05 max	700 app	0.44	Est


Dpt of Environment, Water and Natural Resources
HYPLOT V133 Output 25/03/2018
Period 5 Year 01/01/2014 to 01/01/2019
2014-18
A4260524 L Alex/Milang 821.00 1 Day Mean EC corrected (uS/cm) Continuous AT
1200
1000
800
600
400
200
2014
2015
2016
2017
2018

"A Better Way" for the Murray Darling Basin!

Supplementary to the documentary *Muddied Waters - A Clear Solution.*
2015

And:

- It won't cost the earth – certainly not A$13 billion dollars.
- It won't damage floodplain farms and force farmers from their land.
- No need for water entitlement diversion reductions to service a government wish.
- Will use a portion only of the freshwater volumes currently used for the Lower Lakes etc. with provisions for handing back the balance for productive upstream use.
- No need for costly over-bank flooding and subsequent property damage.
- No disruption for growers - improved growth in Australian foodstuff production and export.
- Growers and communities throughout the basin and the nation will benefit.
- Massive sulphuric acid mobilisation below Lock One will be checked.
- Murray River environments, aquatic life and biota will benefit.
- A working estuary will reward immeasurably with huge benefits because:
- The MDB and the Lower Lakes are within a highly variable system; the Lakes will always be a reversible system – fresh generally during natural flooding and estuarine at all other times.

However: Climate Change with sea level rise is already upon us. It will make all of this inevitable by (circa) 2050. This will affect the 7.6km barrages and all of the barrage embankments between. We should benefit now, and improve our food security rather than wait for the inevitable, while not assisting our growers or our nation today!

Please make this "Today's urgent priority for tomorrows Future!
Anything else may become a poor and costly alternative!

Very much in brief:

To keep the Murray Mouth open nine out of ten years, a former Federal Water Minister ordered large volumes of fresh water flushed down the 2,500km Murray River system. Much will be lost along the way! Upwards of 60% evaporation loss alone is possible across the basin (fmr.*MDBCdata*), and that's without the additional river floodplain constraints issues where additional evaporation and seepage from forcing shallow water over dry, fertile floodplain land will occur, with an extreme likelihood of extensive top soil loss and sediment damage in the water column.

Historically, minimal water flows have been maintained throughout the length of the Murray River since the 1936 completion of the Hume Dam. The Murray system since then is regulated through this storage to assist in avoiding over-bank flooding in narrow sections of the Murray system at all times, save for rare natural flooding occasions. Similarly with large volumes of water released from the Murrumbidgee River storages in recent years, although recent flooding already caused extensive damage, while heightening the concerns for growers.

Given the government proceeds with its "constraints" issues, there is no doubt whatsoever it will cause extensive damage to flood plain property and soils located in these extensive areas where narrower river sections occur, particularly in NSW and Victoria, where fencing, crops, stock, farm infrastructure and bridges etc. will suffer various levels of damage, some will be permanent. Councils throughout river regions including the **13 *Ramroc Group Councils*** are very concerned, while compensation and insurances alone will be difficult for all parties.

There are potential threats to upstream holiday homes in South Australia; notwithstanding a possibility of damage on reaching the lower Murray flats further downstream. There're increasing concerns from among ordinary Australians with little basin connection who are learning about the ways of the authority with its constraints issues. Many are venting their dis-belief that a government and its agency would pursue such a course of destruction and waste.

A waste that would increase with an extra 450 gigalitres proposed in Goolwa SA by the then Prime Minister Julia Gillard as additional to the 2750GL/yr designated up to 2019, to be increased to 3200GL and forced down the Murray and Murrumbidgee systems by about 2024. Reduced volumes have since been discussed during August 2015. Besides, there is no way of sending 450GL into South Australia without property damage.

The *Murray Darling Basin Authority* (*MDBA*) had proposed to increase the flows from the current maximum of between 25,000ML/day and 40,000 ML/day through several severely restricted river flood plain reaches, farms and other properties,

including extensive public and private holdings found along these systems.

As an example, flows three years ago (2012) through the Millewa and Barmah Chokes were controlled at 10,500ML/day and about 8500ML/day respectively.

The original *MDBA* proposal was to fulfill a flow-rate of 2000GL/yr over the Lower Lakes barrages for 95 per cent of the time with a minimum 650GL at all times, in line with what the agency announced in its first *Guide for the Basin Plan*. Simply though, the MDB system and subsequent rain runoff into the catchments doesn't provide enough for additional flows of river water over riverbanks and floodplain expanses, to service a political whim of overbank flooding as the means to additionally cater for the Lower Lakes and the Murray Mouth at the end of system! It's quite apparent, even today how this nonsense will be thwarted by a lack of freshwater.

An important Quote:
From a fact sheet (undated); the former *Murray Darling Basin Commission* **(*MBDC*)** advised its concerns with the *Barmah Choke* on the Upper Murray River system when it wrote, "*there're other environmental challenges in river management with the Barmah Choke. Operating the river for long periods at top-of-bank levels leads to notch erosion and bank instability*." "*The Barmah Choke also limits the ability to target the delivery of environmental flows from upstream storages to downstream icon sites,"* the MDBC said.

Seriously:
None of the proposed, man-forced over-bank flooding impulses down the Murray, the Goulburn and Murrumbidgee systems need occur, notwithstanding the likelihood of extensive property damage and massive water loss. Certainly not when attempting to keep the Murray River mouth clear. Distance and evaporation alone will defeat such a destructive notion!

There is a Solution:
In brief for now, all it will take is one more river Lock; we'll call it ***Lock Zero*** given the current first lock, ***Lock One*** is located some 275km upstream of the Murray Mouth at Blanchetown in South Australia. The Goolwa Barrage will require adjustments while its imperative that civil works remove (or partly remove) an unwanted island that grew from post-barrage times to where its restricts the Mundoo Channel outlet opposite the Murray Mouth by as much as 70%.

Importantly:
History reveals much about the interaction of the Murray River with the Lower Lakes, and the Coorong.

In **pre-barrage times**, it was a variable Lower Lakes when low flows meant the remaining fresh water had to compete with regular Southern Ocean intrusions, as the latter pushed fresh water back into the upper end of the Lower Lakes and on occasions, into the river resulting in a mix of ocean and fresh water, becoming estuarine as naturally found upstream in most global estuaries. Importantly, the

estuarine lakes in pre-barrage times contained extensive water bodies that were extremely useful, with high value outcomes.

Records from these times reveal how estuarine fish populations flourished high up in Lake Alexandrina to where it supported major commercial fishing operations for 44 or so commercial fishers out of Milang and Goolwa, some of whom regularly fished towards the top of Lake Alexandrina area, where they harvested freshwater Murray Cod, Callop (otherwise known as Yellowbelly or Golden Perch) and Mulloway from tidal prism water, often in the same hour, in a nearby location on the same day.

Prior to the barrages (pre-barrage times), each of the fresh and estuarine species were almost plying the same water column save for the natural stratification of fresh water accompanied nearby by mixed estuarine water, at times the fresh still stratified but expected to gradually mix into estuarine water, at which stage the cod would follow freshwater trails for survival while Mulloway remained in estuarine water. Often within close proximity; sometimes found in areas less than a few hundred meters apart. History reveals how Pioneer; Captain Charles Sturt discovered stratified lakes water following his arrival out of the River Murray into the top of Lake Alexandrina.

Commercial fishers primarily established their grounds by taste-testing for fresh water and saline water in the often stratified water columns. These details are provided from an interview by the author of this paper with one of the few remaining Lower Lakes Commercial Fisher identities**,** Mr Victor Woodrow (in his upper eighties today) who fished with his late father during pre-barrage times, during school holidays near the top of Lake Alexandrina, in the area described above until the completion of the Goolwa Barrage. (Mr Woodrow resides in Adelaide today).

Records reveal how flourishing estuarine fish populations in the Lower Lakes came to an abrupt end when the barrages were completed. Following the introduction of the barrages, estuarine fish, invertebrates and general biota once found in the Lower Lakes and sometimes as far upstream at Swan Reach during low flows in pre-barrage times, were shut out from what was previously a magnificent estuarine system. A system that supported a major South Australian fishery supplying SA state fish needs with surplus being railed into Victoria, for almost five decades.

Today, fish species including Mulloway and Black Bream continue to be guided into the Coorong part of the estuary due to their DNA, but the barrages thwart them even though these fish come right up to these concrete structures with a view to reaching the lakes and channels to breed.

It is known through recent fish tagging that Mulloway entering the Glenelg River in Victoria, where this river also meanders slightly into South Australia, that these fish do not breed in this river. Science tells how they rest and feed in the Glenelg

River and then make their way to the Coorong with the notion of entering and breeding in the Lower Lakes.

Some suggest that the basin ends at the real mouth of the river just below Wellington at the head of Lake Alexandrina **and not 45km downstream** at 'the bottom of the lakes, on the south-west outer edge of the Coorong, at the Murray Mouth where the river spills into the Great Southern Ocean.

Significantly:
So long as the barrages are open to exhaust flooding freshwater, with regular high tides and even during neap tides, together with regular, strong prevailing westerly winds, it's inevitable that Southern Ocean intrusions will reverse out-flowing fresh water back through the river mouth, and through the open barrages, pushing fresh and by now, ocean and fresh (estuarine) flows back upstream into Lake Alexandrina, towards the entry point of the Murray River into Lake Alexandrina.

The threat of sea level rise is real so that we can with some certainty expect increases in Ocean intrusion into the Lower Lakes! There're already noticeable signs along Australia's southern coast during winter.

NASA said in its extensive August 26th, 2015 *"Global Climate Change"* data, "*Warming seas and melting ice sheets,"*
"For thousands of years, sea level has remained relatively stable and human communities have settled along the planet's coastlines. But now Earth's seas are rising. Globally, sea level has risen about eight inches (20 centimetres) since the beginning of the 20th century and more than two inches (5 centimetres) in the last 20 years alone."

"Scientists estimate that about one-third of sea level rise is caused by expansion of warmer ocean water, one-third is due to ice loss from the massive Greenland and Antarctic ice sheets and the remaining third attributed to melting mountain glaciers. But the fate of the polar ice sheets could change that ratio and produce more rapid increases in the coming decade," NASA said 10/09/2015. Footnote: NASA, BOM and the CSIRO share their data on climate change.

In the Lower Lakes, Murray Mouth region, evidence has been collected from officially located automatic, real-time beacon probes located across the Lower Lakes and Coorong, streaming out 'real time' probe data and plot readings.

This data is accrued in a central computer storage, where ECu (electrical conductivity unit levels), otherwise known as salinity levels taken from the in-water probes, provide plot readings accurately describing in 'real time,' ocean water ingress as its recorded across the Lower Lakes and Coorong system, as monitored and recorded by government electronic monitoring systems.

These computer findings are regularly monitored by others on hard copy in an exercise to reveal that water in the lakes is often estuarine. A series of plot data

collected by the author and a colleague scientist also reveal ocean ingress occurrences when southern ocean water actually circumnavigated Hindmarsh Island.

There's a huge waste of expensive freshwater entering the lakes with much of this becoming highly saline and wasted. The Lower Lakes aren't lakes but leaky, shallow depressions of sand, silt and river debris culminating in the formation of extensive acidic soils with high levels of seepage and evaporation. They were formed by receding ocean water about 7000 years ago, leaving remaining sand, silt and calcareous ridges that border the lakes and the SE natural drains today. The Lower Lakes combined hold 2018GL.

NE Lake Albert, the smaller of the two lakes at the peak of the Millennium Drought. The black dots are cattle seeking water from an ever-receding lake. Pix by Ken Jury

The 4,500GL annual average of freshwater used in the Lower Lakes, the Goolwa Channel and Murray Mouth region, would have been valued at more than A$10 Billion dollars, had the lakes been full during the peak of the Millennium drought.

The figure of $2.4 million dollars per gigalitre was likely the absolute top tender buyback figure during the Millennium drought, when water was scarce! Water

prices have since fallen with an average tender price for High Security water (for SA) **during 2012-13** standing at about $1.675 million per gigalitre.

This figure puts a value on Lower Lakes stored and used water for an average year at around $7.53 Billion dollars, while the previous Govt. said at the time, they'll continue to send river water towards the river mouth for 9 out of every 10 years.

Basically, precious freshwater is being sent down to evaporate, to be drained and to be wasted in the ocean! This is ludicrous! One wonder's what the return would realise with our food security, when using the same volume of water for additional food grown in the basin over the same period?

There's a much better way:
To make better use of our basin and its limited fresh water, and with the help of free, highly oxygenated Southern Ocean water, another lock (Lock Zero), should be built upstream of Wellington towards Tailem Bend.

A more practical foundation opportunity for another Lock is available today!

As Scientist, Ian *Rowan* BSc Hon. points out, in today's world it's no longer a problem when not locating sound bedrock for river footings, when the use of friction piling has very much become the accepted alternative.

One recent example of friction pile engineering is the Hindmarsh Island Bridge where friction piling was successfully used to hold this massive structure in place.

As old as it is, the Goolwa barrage also sits on a footing using friction piling!

There're benefits to be gained from preventing uncontrolled use and loss of River Murray water in Lake Alexandrina:

An additional lock, Lock Zero should be built and used to regulate minimal freshwater flow into Lake Alexandrina to mix with ocean water, forming and maintaining an estuarine environment, and for the first time, to provide for the control of the pool height between Lock One at Blanchetown and Lock Zero, while providing the means to greatly assist in clearing the Murray Mouth.

This in itself would rid this section of the river of acid mobilization during drought, so bad at times, that even the authorities openly admitted defeat with treatment of mobilized, acid-laden water, notwithstanding a possible threat to the intake pipes that feed water back to Adelaide hills storages.

Returning to an estuarine system during low fresh water flows:
In what would have been a natural occurrence in pre-barrage times, the use of clean, highly oxygenized water from the Southern Ocean, mixed with a

percentage of stored fresh water gradually released from upstream through Lock Zero; the Lower Lakes system would again become estuarine to inundate the lakes and deal with any drying lake or channel mud while limiting acid sulfide development and mobilization throughout the estuarine environment. All without using massive volumes of expensive irrigation water, year after year, which should otherwise be better used to produce Australia's food.

By retaining the barrages, freshly mixed estuarine water could be held within the lakes system for extended periods, and released out of the lakes/channels, from selected barrages to provide strong scouring flows and to regulate the removal of silt and sand from the areas between the barrages and that found in the Murray Mouth outlet to the sea.

Liming highly acidic water and acidic soils in Currency Creek that flows into the Goolwa Channel**.** Pix by Ken Jury.

By using lakes stored estuarine water, the system can be cleaned and flushed at will, while replenishment for the lakes with free ocean water will greatly supplement much smaller qualities of freshwater from behind Lock Zero!

By allowing lake levels to recede by 10 to 20cm only by selective use of barrage gates, estuarine water from the 840 sq km surface of the lakes will provide ample flushing and scouring water for the river mouth.

Scouring the channels and mouth:

Upgrading the barrages will enable restriction of the outgoing flows to elected channel(s), to bias the movement of sand and silt during outflows, and time regulated to suit falling tides.

To enable selective flushing, there should be an upgrading at the Goolwa Barrage where the lifting of multiple barrage compartment concrete logs stacked on top of each other is both cumbersome and time consuming as they're handled individually- one by one by a crane as commonly seen at this barrage today.

Currency Creek succumbs to drought; oxygen reaches cracked acidic soils leading to the mobilization and formation of sulphuric acid to a dangerous ph1.5. Nearby Lake Alexandrina contains at least 500 million tones of acidic soils.

This is an extremely costly and time wasting exercise to continue with when it's necessary to reach the desired scouring out-flow swoosh effects from this barrage.

Lifting single concrete logs this way is far from practical and it's outdated.

The alternative is for a single, thick walled poly tank to fit the existing slots in each of the number of bays in the Goolwa Barrage. Each tank to be fitted with its own pump, to operate in one single lift and fall motion to enable necessary strength in water outflows to clear the mouth and keep it clear, while equally affording opportunity to direct outflows of estuarine water towards the mouth in the northern lagoon of the Coorong.

The lakes themselves would gradually become estuarine again, to develop channels and flats, quickly becoming colonized with estuarine biota associated with the cycles of inundation and exposure to inter-tidal zones.

The savings would be massive:
During average river flow years, the use of ocean water mixed with a 40% portion of fresh would free up a minimum 2700 gigalitres/yr of freshwater being part of what was previously used in the lakes and the channels, now to be re-directed back upstream as surplus freshwater for food production with some towards environmental flows for up-river environments. **There's more, but first:**

Remove this sandy, highly vegetated knoll, shown on page eleven.
Bird Island as its known, faces the river mouth, is located downstream of the Mundoo Barrage and it must be removed as it directly blocks about 70% of the flow from this barrage to the mouth.

This obstruction and a minor connected peninsula gradually formed and vegetated as a result of building the Mundoo barrage. It also impedes movement both ways of Coorong water and water released from the Mundoo Barrage and 3 other barrages within the area that would otherwise clear the mouth of sand and silt.

In consideration of a future for the Lower Lakes system, we should keep in mind how these lakes and nearby channel environs regularly require at least 4500gigalitres/yr of freshwater.

This amount includes top-ups to replace and maintain evaporation and seepage from the shallow lakes, to maintain the channels leading to the river mouth by providing for scouring these extensive systems before & beyond the barrages, and currently, to sacrificially supply regular scouring flushes in failed efforts to keep the mouth open.

Current scouring success rates today are minimal, extremely wasteful and expensive.

On occasions in recent months, larger vessels have not always been able to comfortably navigate across the Coorong adjacent to the inside of the Murray Mouth. Dredging the mouth continues at great expense! That expense in one single decade reached $50 million dollars.

A formula for success:

Combined, the lower lakes hold approx. 2018GL of freshwater at capacity and often it can be highly saline water.
That's approximately 750GL below the original 2,750GL amount of fresh water being sought by the *MDBA* and a former Water Minister from upstream food growers, **as its environmental saviour.**

The Murray Mouth from the west.

With change – we can do with much less:
Simplistic perhaps, but logically there's a view to reduce fresh water maintenance volumes for the lower lakes to just 40%, (about 1800GL/yr) as a freshwater allowance required to mix with barrage entrapped, highly oxygenated Southern Ocean water for the return of a healthy estuarine system within the Lower Lakes.

In order to do so, and as mentioned previously, there will be the need for retaining the barrages (with some minor and in-expensive modification) so that fast manipulation of incoming ocean water and outgoing estuarine water during cleaning the lakes can occur un-impeded.

Albeit, after retaining 40% (1800GL of fresh) for an estuarine mix behind a new lock we've named "Zero", there remains a freshwater balance of 2,700GL as a left-over from an annual average of 4,500|GL/yr previously used within the lakes and for sand, silt and river mouth clearance purposes etc.

This represents a meagre 50GL of the 2750GL MDBA water claw-back figure at the time, dumped upon farmers and irrigators etc., for the environment, and to keep the river mouth clear.

We should also bear in mind a likely additional freshwater saving, over and above from not allowing freshwater into the lakes on its own, to be lost to salinity and massive evaporation and seepage, and that used for clearing the mouth. There're positives here!

A reversal of the system has many possibilities:
There're often seasonal periods when the elected 40% or 1800GL/yr of freshwater required for mixing in the lakes may be further reduced due to seasonal Lofty Ranges rain run-off reaching the lakes. There's a handful of streams that reach the Lower Lakes including Currency Creek and the Finniss and Angus River's that yield significant winter freshwater flows that often reach Lake Alexandrina.

This Lofty Ranges run-off water will again help compensate growers or it could be held as future fresh water meant for the lakes (to mix with ocean water), being held upstream of Lock Zero for this purpose.

Moreover in an adaptive way of thinking, to suit the situation at the time when ensuring the continuity of the estuary or, if additional fresh flows persist through flood or minor flood, then ocean water and river flood water would be adjusted by way of the now rejuvenated barrages and through Lock Zero to suit the situation. In all circumstances the biota throughout will adjust both ways (fresh or estuarine), as it most certainly always does in an estuarine environment!

Estuarine water:
Importantly, estuarine water can be made up of varying volumes of fresh and ocean water, as is naturally the case in most estuarine deltas worldwide. Contrary to claims (and alleged state Govt. tests), estuarine water occurs at varying salinity levels in all estuaries worldwide. It depends on the volume of fresh water flows at the time! These are generally healthy eco-systems that provide immeasurable benefits including commercial and recreational. Ramsar is generally keen to support the values of a healthy, workable estuary.

Returning the Lower Lakes to estuarine would once again create a very useful and beneficial environment. Estuaries 'the world over' are known for their productiveness! Such the case with viable fisheries! It's a known fact that Mulloway (one of many examples of quality commercial fish known to the region) would gradually return to the Lower Lakes again to become part of a major fishing industry, a fish nursery and breeding ground, for the return of a much larger fishery. In turn, tourism would surge ahead and so would development.

How little did the river hold during the Millennium drought?
In our worst drought in history, during the year when about 1100 GL were lost to evaporation from the lakes, a qualified individual had set-about measuring as best he could, water volumes held in the river/anabranches and backwaters between Wellington at the head of Lake Alexandrina and the border with NSW during the same year. The results concluded that evaporation and seepage

claimed a greater loss of water from the Lower Lakes than what the river contained at the same time within the South Australian section of the river. Annually, these water losses alone cost multiple billions of dollars while losses during the worst millennium drought years from the Lower Lakes would have likely reached higher levels in the region.

Flushing the river mouth:

On returning the lakes to an estuary; during periods when flushing is desirable across the Lower Lakes system; carefully selected barrage gates would be opened to coincide with outgoing tidal periods with particular emphasis on directional flow towards the Murray Mouth.

In particular the operation of Mundoo Barrage with released flows moving through Mundoo channel towards its delta that faces the Murray Mouth.

Should the level in the lakes be allowed to fall only 10cm on a single outgoing tide as an example, then this would represent an approximate 75 GL of water that would flow out through selected barrage gates towards the mouth. We're aware through MDBA exercises how 75GL will never clear the river mouth.

However, a 20 cm lakes surface drop would realise somewhere in the order of 150GL that would be used in one single out going, tidal session of approximately 5 hours to successfully scour and clear the mouth.

Volumes of this dimension have only been available in previous flood times, similar to that of the 1956 Flood. Basically, the use of Southern Ocean water becomes the greater component for this estuary and its basically free, while its also provides the means for clearing the mouth region.

Replenishment of ocean water into the lakes can be done often and at will, in a few hours during incoming tidal periods as required.

Due to barrage control of water in and out, marinas should not be affected to where it would be detrimental, providing suitable but simple management strategies are agreed and exercised.

The concrete logs in the Goolwa Barrage represent gates (or logs) that either harness or release water. The Goolwa Barrage is one of five barrages spread over 7.6km, separated by earthen embankments between the remaining four barrages.

An engineering solution is considered regarding the current issue of lifting and manipulating the cumbersome concrete blocks in the Goolwa barrage.

Engineering improvements to the Goolwa Barrage would allow for the faster movement of larger volumes of water. Photo Ken Jury

In the photograph above, removed logs are shown on the top of the barrage to the right, just beyond one of two rail lines that support a crane (out of shot) used as the mobile lifting or lowering device across the barrage. The other rail line is found slightly right of the pedestrian walk. Log slots are located centrally in the structure, as seen across the top, in every bay across the barrage where individual logs are lowered down between the protective steel lined slots found at either end of each bay, to accept individually inserted or removed logs.

There is a view, these logs should be replaced with a single, much lighter polyethylene tank to each bay, to fit the same slot width and full height dimensions of this barrage, in each single bay compartment instead of a stack of cumbersome concrete blocks so that each can be raised and lowered with a simple water hydraulic ram/bag pressurised by a common pump.
We believe that the use of purposely built high quality, UV stabilised and reinforced polyethylene single tanks would be equally robust to that of concrete, while providing a lighter, faster and more economic method of water management through the barrages.

These could easily and quickly be manufactured locally. The ram would press against a boom (tappet- like) over each gate (tank) with the hydraulic pressure delivered to each ram by piping from a single pump. Leakage under this circumstance would not be an issue as the fluid for the hydraulics is the water already located at the source of the need, and tank lowering need only drop the ram and expel the water through a simple valve.

I believe that selective lifting of multiple blocks across the barrages in a single action will provide the necessary estuarine water outflows to clear the mouth and

keep it clear while affording opportunity to direct outflows or inflows of clean ocean water or to expel outflows of ocean/freshwater towards the mouth and, to offer minimal assistance to the southern end of the northern lagoon of the Coorong.

Importantly, my colleagues and I share the belief that neither the former 2750GL/yr nor 3,200Gl/yr would have made any useful difference to keeping the mouth of the river clear. There are many reasons including the fact that most of this water, when available would be sent downriver to be lost.

Furthermore, and as an example in 2011; during the months of March to May in that year, a remnant minor flood came down the river whereby flows of up to 80GL/day passed the Goolwa wharf and through the opened barrage gates. Flows at this rate made no discernable difference to the sand bars and the depth of the channel through the Murray Mouth.

In fact at the time, prevailing wind and tides pushed much of this water back through the open barrages, as is the case on many occasions during autumn and winter. Wind Seiche in particular, (the gentle blowing of water across a saucer) plays a large part in mixing ocean and freshwater into estuarine, while it also alters the AHD ‘s (Australian Height Datum Levels) during windy days.

Up to two dredges currently operate 24/7 today, to keep the mouth clear.

Note to assist readers: A single gigalitre is equal to one km x one km by one metre deep.

The weight and power behind the volumes of freshwater sent downstream in recent times are hard pressed to match the weight and push of the mighty southern ocean and with water availability waning, one would seriously expect that the Lower Lakes should not be kept in a freshwater condition only.

Ken Jury, Senior Investigative Journalist (Marine & Aquatic Ecology).
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, SA

Please note: My documents are generally ‘Work in Progress.’

Overbank run-off !

It's A River Killer!

Natural flooding from rain events across the Murray Darling Basin is extremely rare and unavoidable. Practicing controlled overbank flooding will always pick up on destructive sediments that will reach and destroy our rivers. No amount of environmental diligence or empathy with overbank flooding will save the quality of our river water, nor the expected property damage.

Soil-laden sediment is often very fine, loose stuff found in floodplain sand, clay or soil so why did the Murray Darling Basin Authority not consider the words watershed-spill and what that may contain, from day one?

Sedimentation begins as a dry and often-unhealthy particulate matter from erosion and plant decomposition on watershed floodplain landscapes, until its disturbed and carried by water run-off towards our basin rivers!

A watershed may be a tilted or raised strip of arable land that separates water flowing into rivers, anabranches or storages. It may be a section of land that could further drain to an even larger watershed and so on, to where it eventually flows over riverbanks into river channels, often causing notch erosion to the top edges of riverbanks.

The sedimentation of rivers in the basin streams and water storages, and even in the Coorong located at the delta end of the Murray Darling Basin in South Australia, represent a major invasive river pollutant that's not only damaging the quality of our river water throughout, but also the various biota reliant upon aquatic vegetation which is also being destroyed in river beds.

Sediments do destroy aquatic habitats and the organisms within.

So, where do our Basin Rivers and backwaters in the Murray Darling Basin sit with water quality and in-river environmental degradation?

For a clear insight, we look to Federation University Australia's ***Water Research Network's*** Professor Peter Gell, ***Professor of Environmental Management,*** for details following his extensive fieldwork across the basin including South Australia's Coorong. In an Extended Abstract ***"Prospects For Ecological Recovery In Wetlands Limited By Muddy Murray Flows"*** by Professor Gell, we find how *"Australia has embarked on a*

significant, and expensive, environmental flows program to restore the ecology of the Murray Darling Basin."

Professor Gell said how *"restoration programs have been underpinned by the focus on river flows that cause system degradation."*

So, how widespread and damaging are these problems?

"*The condition of the aquatic ecosystems of the Murray Darling Basin has been recognised as widely degraded and a key Ramsar site has been declared to be in crisis. This poor state has largely been a consequence of the high level of regulation and diversion of surface waters, in particular for the development of a highly productive irrigated industry, although declining water quality is also evident,"* he said.

It's then clear; our basin water quality is in question as are many of the river habitats throughout!

Professor Gell's Extended Abstract gets down to business with what we often contemplate when staring into a river; wondering what conditions may prevail in the bottom of the river?

'T*he long term records also attest to the rapid infilling of shallow wetlands and their likely territorialisation in the absence of future scouring flows. They also reveal regime shift changes driven by changes to the light environment from chronic high water turbidity,"* he said.

"*Further, sediment source studies reveal water to be the principal vector for the continued supply of fine sediments in wetlands questioning the anticipated wetland recovery from watering. Investment in the mitigation of sediment flux is essential if the community is to reap the full benefits of the allocation of contested water volumes to the environment,"* Professor Gell said.

Today, it's about the quality of freshwater across basin rivers including freshwater reaching the upper Coorong in South Australia!

In July 2017, details were released concerning the quality of water throughout all basin rivers and the Coorong. From these extensive field research investigations across most basin rivers, scientists discovered finely granulated sedimentation loading suspended in upper levels of water columns. Suspended sediments impede or blocks sunlight penetration through the upper water column so that it doesn't reach river substrates across most basin systems. This sedimentation condition is to the detriment of an array of aquatic biota below including important aquatic vegetation, fish, molluscs and crustacean, as well as the necessary quality of fresh water within the basin river systems. It affects water quality for many, including growers, basin communities aquatic life.

This places future water procurement expectations concerning the health of our water resources across the basin, under an additional but necessary spotlight!

It also brings back into focus what is considered a right by the MDBA to create a wider 'greenbelt' beyond the natural river channels by processes involving overbank flooding. Practising this to actively water vegetation that's ordinarily, and naturally watered by rainfall precipitation. At any time and any level, this practice is damaging and costly!

Once again though, scientific history has been discarded! ***"In summary, the current operating system for the Lower Lakes and Murray Mouth is not sustainable with continued significant environmental degradation expected,"*** the former Murray Darling Basin Commission advised back in the year 2000.

Meanwhile, Palaeoecologist, Professor Peter Gell from Ballarat Federation University, in a recent interview with ***The Land*** newspaper told of "*Serious turbidity from increased sedimentation particulate in mid-river wetlands and even in the Coorong is now scientifically tested and acknowledged. The decline came to the attention of scientists from core sampling that exposed 7000 years of fine, settling materials such as sediment on to the submerged landfall. These findings are the results of several decades of core sampling and other investigative work,"* according to Professor Peter Gell.

"*In the Coorong the sediments are coarse shelly marl prior to the establishment of the barrages, after which fine, organic muds accumulate. Above, many wetlands accumulate sediments only after regulation and, before then, were likely dry enough for the sediments to blow away. So, their natural wetting regime is irregular. Now, they are tied to a stable, wet system and continuous sediment accumulation is the new normal. Scarily, this is occurring at 2-5cm/yr and so these depressions are filling up quickly with mud, and are so turbid, there is not enough sunlight reaching the bottom for plants to grow actively. Frequent watering of these sites with turbid water is unlikely to stimulate plant growth and is contributing to net sediment accumulation,*" he said.

According to Prof Gell, we should explore the options for Lake Alexandrina,
In readiness for the next big drought. He questions whether we're to aerially release mulch, while calling for river flows when there are none, or to allow the sea in and protect freshwater habitats such as the Currency Creek and Finniss River deltas with low barrage barriers.

With a wide focus on water quality, all plants and other organisms rely on photosynthesis to synthesize nutrients from water. Sedimentation affected wetlands include those that may already have questionable ***Ramsar*** connections, including those of the Lower Lakes and Coorong region. Widespread particulate in the upper water column could badly disrupt or destroy water quality across the food bowl, throughout all of the Murray Darling Basin river systems.

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SPECIAL ISSUE

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Perspective

Watching the tide roll away – advocacy and the obfuscation of evidence

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Abstract. The Murray–Darling Basin Plan represents the largest investment in an Australian environmental management issue and remains highly conflicted owing to the contested allocation of diminishing water resources. Central to the decision to reallocate consumptive water to environmental purposes was the case made to keep the terminal lakes in a freshwater condition. This freshwater state was identified as the natural condition on the basis of selected anecdotal evidence and was enshrined in the listing of the site under the Ramsar Convention. Independent evidence from water quality indicators (diatoms) preserved in lake and lagoon sediment records, however, attested to an estuarine, albeit variable, condition before the commissioning of near-mouth barrages in 1940. Political pressure saw the interpretation for a naturally estuarine history published after peer review, revised and released under state government sanction without review or acknowledgement of the original research. This act of intellectual suppression was the outcome of scientists succumbing to the temptation of advocacy for environmental flows. In the end the clear contradictions between the published evidence and the advocated interpretation has diminished credibility in the science behind the Basin Plan and acted to fuel discontent in those affected by water reallocations.

Additional keywords: intellectual suppression, ecological condition, Murray–Darling Basin, palaeolimnology, Ramsar wetlands

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Introduction

The Murray–Darling Basin is Australia's largest catchment, spanning more than one million square kilometres. It is also its most productive, hosting over 40% of the nation's agricultural domestic product. This productivity has been underpinned by an extremely high level of water abstraction to drive intensive irrigation agriculture at great cost to water-dependent ecosystems. Originally to sustain navigation, but ultimately to guarantee water supplies, the rivers of the basin became highly regulated after the commissioning of many dams and weirs, mostly after 1922.

The initial efforts at irrigation were limited and focussed in the upper reaches of the Murray and Goulburn Rivers. Nevertheless, concern regarding the impact of off-take on the on-flows to South Australia was sufficient to warrant a presentation and debate within the South Australian Parliament as early as 1886. For example, the honorary Jon Rankine is quoted as saying in the House of Assembly in 1887 that 'Many people imagined that there would be nothing to fear from only flood waters being taken, but this was a great mistake. All the floodwaters were required to drive out the salt water so as to keep the lakes and a portion of the lower river fresh for a few months in the year' (Sim and Muller 2004: 26). This dispute intensified and became an important distraction to the nation's Federation, signed in 1901. The interstate royal commission into the basin (Davis *et al.* 1902) was to resolve this issue and by 1907 the Murray River Commission was instituted to manage cross-state contests over water.

The Coorong and Lower Lakes lie at the mouth of the basin and are a lagoon and estuarine complex (Fig. 1). To preserve freshwater resources in Lake Alexandrina from the penetration of tidal waters barrages were commissioned and completed in 1940. These were situated near the river's mouth and acted to raise the level of the lake and hold back incoming tides. They also slowed river flow, leading to the accumulation of salt-laden sediments, the formation of Bird Island, a tidal delta south of Hindmarsh Island, and the northward migration and ultimate closure of the river mouth (Bourman *et al.* 2000).

In 1985 the Coorong and Lower lakes were listed under the Ramsar Convention owing to the significant fish and waterbird populations and cultural significance. At the time the lakes were described as being mostly fresh (DEH 2000). Reinforcing this, a report entitled 'A Fresh History', funded by a regional government agency, defined the lake as being predominantly fresh (Sim and Muller 2004). This report was largely based on documentary and anecdotal evidence and focussed particularly on the observation that, in 1901, the lake had become salty for the first time. This was attributed to abstraction upstream for irrigation in the eastern states, particularly in neighbouring Victoria.

Advocacy to restore the ecosystems of the Murray–Darling Basin was in full swing by the late 20th century, with several reviews and audits conducted. Among the outcomes are the identification of the volumes required to return the system to

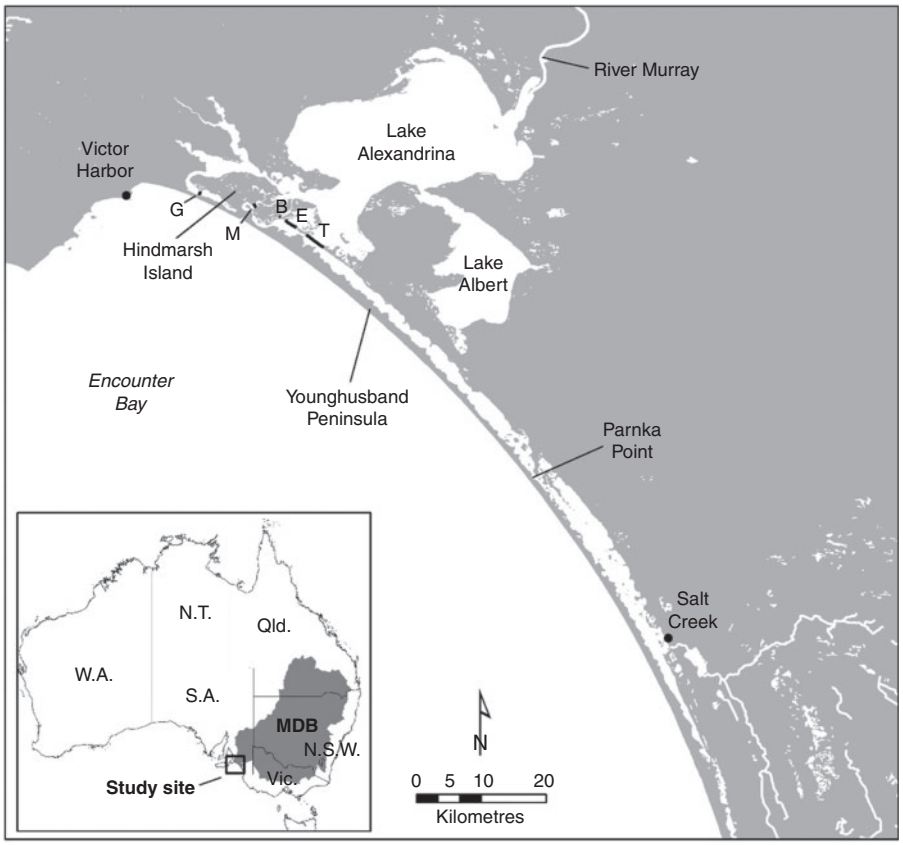

Fig. 1. Lake Alexandrina is a large terminal lake near the mouth of the River Murray, South Australia. Letters mark the locations of barrages.

ecological health (e.g. Jones *et al.* 2002). The South Australian Government argued for the allocation of large volumes of water to retain the lower lakes in a freshwater state. This was advocated on the basis of its natural ecological character, not least because that was the condition defined in the listing under Ramsar. This is the default baseline state under the Ramsar Convention in the absence of evidence for prior natural ecological character (Pittock *et al.* 2010). The decision to return 2750 GL year^{-1} to the river, through buybacks and water transfer efficiencies, was made, in no small part, because it was effectively argued that Australia had an international commitment to retaining Lake Alexandrina as a freshwater lake. Federal and State Governments agreed to allocate a further 450 GL where it can be demonstrated that this would accrue no socioeconomic hardship to communities in the Basin (MDBA 2012).

Palaeolimnological research

Lakes and estuaries contain sediments that accumulate more or less continuously over time (Weckstrom *et al.* 2017). Buried with these sediments are chemical and biological remains that reflect the nature of the wetland at the time of sediment deposition. The collection of sediment cores, the subsampling of sediments and the identification of these remains allows for the condition of the wetland to be inferred. In estuaries this usually allows for a 7000-year history to be outlined as this was the point in geological history that sea levels last stabilised and geomorphic evolution of present-day coastal wetlands commenced. Diatoms are particularly useful fossil bioindicators of estuarine condition (Taffs *et al.* 2017) owing to their abundance, diversity and close association with, and widespread calibration to, water chemistry (e.g. Gell 1997).

Barnett (1994) analysed sediment cores from Lake Alexandrina and concluded that the lake was estuarine from 7000 years ago, but variable on account of climate variability, but was fresher in the modern period. A core taken, but not analysed, by Barnett (LA2), and another collected by Gell and Fluin in 1996 near the river entrance (LA1), formed the basis of analyses in Fluin (2002). The evidence derived from cores collected from the Coorong by Gell and colleagues was reported to the South Australian Department of Water, Land and Biodiversity Conservation in Gell and Haynes (2005) and is detailed in Gell (2017). The interpretation of the interactions between the river, the lakes and the Coorong were presented at the Past Global Changes 'Salinity, Climate Change and Salinisation' workshop in Mildura in September 2004 (Gell *et al.* 2007) and subsequently published as Fluin *et al.* (2007). The published records of fossilised diatoms in the two Lake Alexandrina cores reveal changes in key indicator taxa over the last 7000 years. Non-contiguous subsampling leaves out much of the record but the data reveal gradual changes, attributed to hydroclimate change, until the commissioning of the barrages.

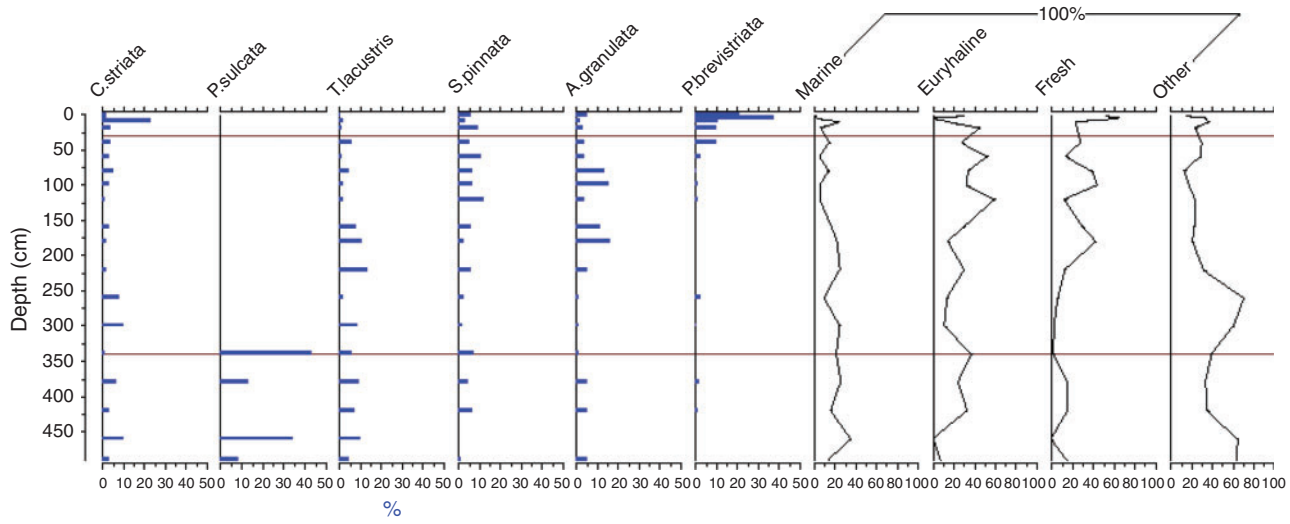

Fig. 2. Summary diagram of the diatom stratigraphy of core LA2 (based on Fluin *et al.* 2007).

Critical to the interpretation of the fossil records is the understanding of the ecological preferences of the taxa preserved in the sediments. This is largely achieved through the collection of modern diatom specimens and the calibration of the relative abundance of these to measured water quality parameters. This was achieved for diatoms from inland salt lakes (Gell 1997) and was completed for some Australian estuaries (Haynes *et al.* 2011; Saunders 2011; Logan and Taffs 2013). As diatoms are ecologically conservative and largely cosmopolitan, interpretation of Australian fossil sequences can benefit from the ecological preferences identified from databases developed elsewhere across the world. It is clear that the taxa considered marine or estuarine in Fluin *et al.* (2007) – *Cyclotella striata*, *Paralia sulcata* and *Thalassiosira lacustris* – are indeed reflective of marine conditions (see Appendix 1 for detailed review of the known ecology of these taxa). None were recorded from inland salt lakes (Gell 1997) and so their presence reflects saline or subsaline conditions influenced by waters of marine (thalassic) origin. Other key taxa in the LA2 record were *Staurosirella* (syn. *Fragilaria*) *pinnata* and *Pseudostaurosira* (syn. *Fragilaria*) *brevistriata*. Both were recorded in inland lakes with weighted average salinity optima of 3.9 g L^{-1} and 1.9 g L^{-1} respectively. Gell and Haynes (2005) and Fluin *et al.* (2007) reported *Staurosirella pinnata* to be abundant in the upper sediments of both the north and south lagoons of the Coorong, which is, and has been in historic times, saline to hypersaline. It was also recorded to be abundant in lakes of 6.3 g L^{-1} and above in Gell (1997). On the basis of this evidence *S. pinnata* appears to be highly salt tolerant; *P. brevistriata*, on the other hand, is regarded as an obligate freshwater taxon. While these diatoms are broadly tolerant, these inferred preferences are used to summarise the change in condition of Lake Alexandrina, as revealed from core LA2, and presented in Fig. 2.

The Fluin *et al.* (2007) interpretation

In reference to the high incidence of thalassic taxa in the early part (~7000–5000 years BP) of the record, Fluin *et al.* (2007: 130) stated 'The presence of *Thalassiosira lacustris*, *Cyclotella striata* and *Paralia sulcata* indicate marine influence at this time …' and '… the change in diatom community [after 5000 years BP] is likely to represent a decrease in lake level and increased penetration of seawater, possibly associated with the variable, dry climate phase after the mid-Holocene wet phase'.

The return to regional wet conditions is reflected in the passage '… The decline in *Thalassiosira lacustris* above 160 cm [~2200 years BP] marks a further increase in freshwater river input conditions, perhaps influenced by the increases in precipitation' (Fluin *et al.* 2007: 130).

Acknowledging the prevalence of athalassic taxa, Fluin *et al.* (2007) stated: 'The Holocene diatom assemblages of Lake Alexandrina reflect relatively freshwater conditions with long-standing and major inputs from the River Murray. Marine water indicators were never dominant in Lake Alexandrina'.

It did, however, clearly articulate the post-barrage change to freshwater conditions, stating: 'The barrages completely separate both lakes from the Coorong, with infrequent fresh water flowing through the barrage gates. As a result, Lake Alexandrina is *presently* [my emphasis] a large, predominantly fresh water system with no salt water input', and 'The greatest change to the diatom flora is again near the surface, at 30 cm, mostly attributable to a strong increase in *Pseudostaurosira brevistriata* coinciding with the estimated time boundary for the onset of river regulation. Further this increase is associated with a small decrease in *Staurosirella pinnata* that may be attributable to the barrages controlling tidal flux to the Lake favouring *Pseudostaurosira brevistriata*, which has a lower salinity tolerance than *Staurosirella pinnata*' (Fluin *et al.* 2007: 130).

In summary, it stated that salinity in the large terminal Lake Alexandrina was only moderately influenced by tidal inflow, particularly over the past ~2000 years. It is now [i.e. today] largely fresh as a result of isolation by a series of barriers completed by 1940 AD. Unequivocally, Fluin *et al.* (2007) stated that, before regulation, Lake Alexandrina was tidal with the balance between marine and river influence attributable to the regional hydroclimate as revealed in the water balance

records of the 'rain gauge' lakes of western Victoria. The greatest change in the entire record, as revealed by the cluster analysis, was after the commissioning of the barrages, whereupon the diatom flora reflected unprecedented, freshwater conditions. The interpretation of Fluin *et al.* (2007) is consistent with those presented in Fluin (2002).

The fresh history (Sim and Muller 2004)

Coincident with the compilation of the palaeolimnological research of Fluin on Lake Alexandrina the River Murray Catchment Water Management Board published a document (Sim and Muller 2004: 1) that concluded that 'Prior to European settlement, Lakes Alexandrina and Albert at the terminus of the River Murray were *predominately* fresh …'. Further, it stated (Sim and Muller 2004: 1) that 'Contrary to what many believe today, saltwater intrusions into the Lake environment were not common until after 1900 when significant water resource development had occurred in the River Murray system'.

The interpretations of Sim and Muller (2004) are founded on anecdotes, particularly through the time of the Federation Drought, but also across the years ~1820–1940. As such, it provides a synthesis of the commentary within South Australia as to the changing nature of the lake and the lower reaches of the river. They noted (Sim and Muller 2004: 1) that 'Short-lived intrusions of saltwater would occur during periods of low flow down river resulting in a lowered level of water in the lakes. Even in times of these low flows, it would appear that only small areas of the Lakes were affected' and that 'Saline invasions were more common after 1900 and the development of irrigation works because reduced river flows could not hold back the sea' (Sim and Muller 2004: 1).

The years around 1900 were characterised by one of the more significant droughts in documented history and the reconstruction of hydroclimate since 1788 (Gergis *et al.* 2012) reveals it to have coincided with a substantial shift in the Pacific Decadal Oscillation relative to 230 years of variability. This was conceded thus: 'Irrigation schemes began at the same time as a long lasting, widespread drought that further diminished the amount of water in the river system (Sim and Muller 2004: 1)'.

What Sim and Muller failed to report was the findings of the Interstate Royal Commission that were contrary to their selective position. The Commissioners represented three states and sought counsel from across the Basin, and not just from South Australians. Davis *et al.* (1902) reported many observations including 'One effect of a deep entrance channel would be to increase the saltness of the lakes, which, after a strong northwest or westerly gale, are brackish; the salt water being forced up channels as far as Wellington' (Davis *et al.* 1902: 33). Further, they reported the observations that 'When the winds shift to the south-east it is again blown out of the lake, a greater quantity running out under these circumstances than during any river flood' (Davis *et al.* 1902: 33–34) and that of the master of a trading boat who is quoted as saying 'he had known the water of the lakes as salt in past years' (Davis *et al.* 1902: 34). Ultimately, they concluded that: 'Apart from verbal statements, the evidence of facts is against the hypothesis that there has been any increase in saltness in the Murray Lakes by reason of diversion of water from the river channel' (Davis *et al.* 1902: 34).

Table 1. Alterations to passages found in both Fluin *et al.* (2007) and in Fluin *et al.* (2009)

Passage in Fluin *et al.* (2007: 130)	Passage in Fluin *et al.* (2009)
'The presence of *Thalassiosira lacustris*, *Cyclotella striata* and *Paralia sulcata* **indicate marine influence** at this time' (2007: 130)	'The presence of *Thalassiosira lacustris, Cyclotella striata* and *Paralia sulcata* indicate **minor** marine influence at this time'
'… the change in diatom community [after 5000 years BP] is likely to represent a decrease in lake level and increased penetration of **seawater**, possibly associated with the variable, dry climate …' (2007: 130)	'… the change in diatom community is likely to represent a decrease in lake level and increased penetration of **more brackish water**, possible associated with the variable, dry climate …'

Sim and Muller (2004) does not report on these contrary views reported in Davis *et al.* (1902). Given that this would have been regarded, less parochially, as the authoritative document of the time, it is clear that Sim and Muller (2004) represents a subset of the views available. For Davis *et al.* (1902) to come to a conclusion, on balance, that is so markedly different to that given in Sim and Muller (2004) suggests that the reporting in the latter was highly selective.

The new interpretation from Fluin *et al.* (2009)

From 2010 a new report was posted on the South Australian Government website. Entitled 'An Environmental History of the Lower Lakes and The Coorong', this report on the palaeolimnology of both Lake Alexandrina and the Coorong lagoon was produced by three of the five authors of the 2007 publication but was not published (nor paginated).

Using the same diagrams and descriptions as Fluin *et al.* (2007), Fluin *et al.* (2009) concluded: 'There is no evidence in the 7000 year record of substantial marine incursions into Lake Alexandrina', yet they also stated 'There were substantial alterations to the diatom community in Lake Alexandrina following European settlement and particularly after barrage installation'. In contradiction to the evidence presented in Fluin *et al.* (2007) they asserted that: 'Over the 7000 year record, there are minimal numbers (generally <10%) of estuarine diatoms' and that '… estuarine conditions have essentially been absent from this section (LA1) of the lake (<5%)'.

The entire interpretation of the LA2 record in Fluin *et al.* (2009) can be found, *word for word*, from the same section in the 2007 paper but with two small, but significant, changes (Table 1). Specifically, the words 'marine influence' (Fluin *et al.* 2007: 130) are altered to 'minor marine influence', and 'increased penetration of seawater' (Fluin *et al.* 2007: 130) is altered to 'increased penetration of more brackish water'. Both alterations diminish the interpretation of a tidal influence on the ecological character of Lake Alexandrina. The second alteration creates confusion as the term brackish cannot be qualified, it meaning salty waters, usually the result of freshwater mixing with seawater. So, the use of the terms 'minor' and 'brackish' serve to preclude the ocean as a source of lake water salinity.

Given that the relevant passage in Fluin *et al.* (2009) can be found word-for-word in Fluin *et al.* (2007), except for four

Table 2. Details of seven papers that have used Fluin *et al.* (2007) to argue for a fresh history

Paper	Quote
Mosley *et al.* (2012): 3925	'The river channel discharges into the large (821.7 km^2 total surface area) and shallow Lower Lakes, which are freshwater, eutrophic, and highly turbid (Geddes 1984; Fluin *et al.* 2007; Cook *et al.* 2009)'.
Mahon *et al.* (2015): 1491	'The installation of tidal barrages and weirs near the mouth of the system (~1940–50s) to prevent incursion of marine water resulting from upstream hydrological abstraction, modified the hydrology and ecology of extensive freshwater lakes known as the Lower Lakes (LL) and the Coorong estuary (Fluin *et al.* 2007; Wedderburn *et al.* 2002)'.
Hammer *et al.* (2013): 807	'This [regulation; flow reductions] has jeopardised the future of a long-term freshwater refuge and biodiversity hotspot (Phillips and Muller 2006; Fluin *et al.* 2007; Kingsford *et al.* 2011)'.
Wedderburn *et al.* (2012): 36	'… barrages were constructed in ~1940 in response to river regulation and water abstraction that was causing periodic marine incursion in an otherwise predominately freshwater environment (Fluin *et al.* 2007)'.
Kingsford *et al.* (2011): 257	'Historically, the water in the lake was mainly fresh, indicated by freshwater diatom tests (95%) accumulated in the sediments over the past 7000 years (Barnett 1994; Fluin *et al.* 2007)'.
Brookes *et al.* (2015): 192	'Lake Alexandrina was estuarine prior to construction of the barrages, although paleolimnological evidence suggests it was predominantly fresh (Fluin *et al.* 2007) as river flows restricted the tidal ingress proximal to the Murray Mouth'.
Hammer *et al.* (2010): 221	'In addition, the occurrence of *N. obscura* within MDB only in Lake Alexandrina supports information that this water body has been a predominantly fresh habitat over thousands of years (Sim and Muller 2004; Fluin *et al.* 2007)'.

words that dramatically change the interpretation to one more consistent with a freshwater history, questions can be raised of the authors as to the justification for the new interpretation. Certainly, Fluin *et al.* (2009) offers no new palaeolimnological evidence, or new knowledge of the preferences of the key species, to lead to a reinterpretation. While a motive cannot be ascribed at this point, insight may be gained from a quote from a local from the Lake region cited in Gross *et al.* (2012: 59) who observed 'The incentive for returning large volumes of water as environmental flows is reduced in an 'estuarine' perspective of the lakes'.

How the evidence has been used?

A brief exploration of the Scopus website (www.scopus.com) of instances in which Fluin *et al.* (2007) has been cited in the scientific literature reveals it to have been cited on 44 occasions. Of these, 17 were self cites, 2 were in outputs too obscure to retrieve, 8 were on matters of diatom ecology or related to determinations of sedimentation rate, and 8 pertained specifically to the Coorong and not the lakes. Of the remaining 9 citations, 7 misrepresented the findings reported in Fluin *et al.* (2007). As Table 2 shows, most of these used the evidence from the palaeolimnological record to attest to a permanent freshwater history, when the original paper, while suggesting a fresher condition under wetter climates, and a freshwater state after regulation in 1940, did not state that the lake was 'predominantly fresh' or 'a freshwater refuge'. It remains to be seen whether these authors have sought authority by reference to Fluin *et al.* (2009), but when instructed under review that that paper is neither reviewed nor published, have merely cited Fluin *et al.* (2007), unaware that the two have contrasting conclusions.

As the debate pertaining to the restoration of the Murray–Darling Basin has intensified, a composition (coauthored by Gell) submitted to *The Conversation* (Finlayson *et al.* 2017) drew a particularly misguided post (https://theconversation.com/we-need-more-than-just-extra-water-to-save-the-murray-darling-basin-80188):

> 'This has been studied using remains of diatoms, which neatly signal whether environments are saline, brackish or fresh, and *they show unambiguously that for the last 7000 years Lake Alexandrina was a freshwater environment* with only a few brief incursions of saltwater during extreme drought events (which over a 7000 time-span, you will have a few of). So yes, the lakes were indeed *predominately fresh* before white man modification/water extraction. A dry read but one such paper detailing this evidence is: Fluin J, Gell P, Haynes D, Tibby J, Hancock G. (2007). Paleolimnological evidence for the independent evolution of neighbouring terminal lakes, the Murray Darling Basin, Australia. Hydrobiologia 591: 117–134.'

The author of this post drew a conclusion as to the history of the condition of Lake Alexandrina over the last 7000 years and then cited the paper from which this conclusion was drawn, seemingly unaware that Gell was a coauthor of both the 2007 publication and the piece in *The Conversation*. Remarkably, the author's summary does not reflect the conclusion of the paper cited.

These authors likely have used Fluin *et al.* (2007) to lend authority to a state they themselves had surmised. How did they get it so wrong? Possible alternatives include:

- they read Fluin *et al.* (2007) and concluded that the authors said, or intended to say, that the lake was 'predominently fresh' thereby exhibiting 'confirmation bias' (*sensu* Berger and Johnston 2015);
- they assumed that the condition was 'predominantly fresh' and used Fluin *et al.* (2007) as an authority without checking;
- they took the opinion of Sim and Muller (2004) that the lake was 'predominantly fresh' but sought, or were required under review, to cite peer-reviewed evidence to that effect, and failed to check;
- they had read Fluin *et al.* (2009), which provided them with the evidence that the lake was 'predominantly fresh' but, because it was not a published document, elected, or were required under review, to cite Fluin *et al.* (2007) as the authority;
- they read and fully understood the conclusions in Fluin *et al.* (2007) but elected to state that the lake was 'predominantly fresh' and still elected to cite Fluin *et al.* (2007) as the authority.

These options leave open as to whether these papers, and the post to *The Conversation*, reflect an instance of anything ranging from poor checking of the cited paper, to laziness, to deliberate obfuscation of the evidence presented. Maybe the authors have succumbed to confirmation bias or perhaps they were drawn, independent of the published evidence, to advocate a position that was consistent with the case calling for environmental flows under the Basin Plan. Irrespective, it seems that the science community has interfered with the honest representation of the palaeolimnological evidence and so has manipulated the socio-political decision-making process that has laid down a decision of great consequence.

Advocacy and evidence

Postmodern deconstruction of scientific evidence dispels the myth that science is always entirely objective. Head (1995), for example, neatly portrayed the likely inherent biases in the condition of the author of the *Future Eaters* (Flannery 1994), the celebrated version of the coevolution of the Australian landscape and its people. It is nigh impossible for a scientist to remain absolutely objective and society always ought to contextualise the author or speaker when absorbing the evidence put, particularly when a position is advocated.

In the acute regional contest under the allocation of water under the Murray–Darling Basin Plan, we have here evidence for the intrusion of political stakeholder bias in the reinterpretation of peer-reviewed published science. These interpretations may have been misled by the unpublished Fluin *et al.* (2009) report but this reveals poor attention to detail and a shallow review of the evidence. One fears that these contrary observations have suffered from an inclination to mix science with advocacy and the standards of one have been compromised by the pursuit of the other. In particular, in the absence of a case made to reinterpret the inferences made in Fluin *et al.* (2007), it is difficult to conclude otherwise in the instance of Fluin *et al.* (2009) itself.

While I have been trained to abide the razor edge of representing the evidence and neither advocating for either case in, for example, a development proposal, I personally understand when a scientist lapses into advocacy convinced that the best cause is served. Here, however, is an example, where this fatal step has undermined the credibility of sound science, and steered the debate into further conflict when its original purpose, by way of its unique access to the time dimension, was to resolve the hitherto unresolvable. Perhaps the most critical lesson here is how this saga played out in the media and in the politics. Dr Jennifer Marohasy exposed the duplicitous nature of the interpretation in Fluin *et al.* (2009) and labelled it as 'Junk Science' (Marohasy 2012), only to be pilloried in the ABC program *Media Watch* (19 March 2012; see also http://jennifermarohasy.com/2012/05/media-watch-witch-hunt/). Today, lobbyists seeking to limit the impacts of the Basin Plan on irrigation agriculture make use of this manipulation of evidence to seek to undermine the allocation of environmental flows.

In the end it is reasonable to ask why has a report that used and reinterpreted a published paper, and made conclusions that could not be substantiated by the evidence, been allowed to remain on a State Government website for others to misrepresent the science? The warning for us all in mixing science and advocacy is that the political process has no conscience and reputations are easily dashed. Upholding respect for our science demands that we report it with integrity and then, as members of society, seek to participate in the challenging processes that make decisions that affect people and their places.

Conflicts of interest

PG was an associate supervisor in the production of Fluin (2002) and was a co-author of Fluin *et al.* (2007).

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Appendix 1. Ecological preferences of key fossil indicator taxa

Cyclotella striata

The *Cyclotella striata* species complex includes numerous species and subspecies with similar morphology (Håkansson 1996). Problems exist surrounding the identification of these centric species, in part because, in saline inland lakes, estuaries and lakes with high conductivities, there are a mix of marine and freshwater species and often the nomenclature has been guided by the ecology of the species being named (Håkansson 1996). *Cyclotella* has a wide environmental tolerance, but only eight species have been found in saline waters (Olvia *et al.* 2008), including those in the *C. striata* complex. *Cyclotella striata sensu stricto* has been described as being prevalent in brackish, marine, estuarine and inland saline lakes (Bradbury *et al.* 1981; Jiang *et al.* 1997; Saunders *et al.* 2008; Cook *et al.* 2016). It was regarded by Roetzel *et al.* (2006) as being allochthonous euryhaline (able to adapt to a wide range of salinities). Jiang *et al.* (1997) attributed a rapid increase in *C. striata* in a core from the north-eastern Atlantic margin to a decrease in sea salinity as a result of strong coastal currents and global sea level rise. They also observed it commonly in the spring plankton in estuaries along the North Sea coast. While Pokras (1991) reported *C. striata* as a brackish water species from the Zaire River, Africa, Marshall and Alden (1990) referred to it as being a freshwater species abundant in the estuarine rivers of the Lower Chesapeake Bay, USA. Declining abundance of *C. striata* in Chesapeake Bay cores was associated with increase turbidity and eutrophic conditions following European settlement in the 18th century (Marshall *et al.* 2005).

Paralia sulcata

Paralia sulcata has been reported in waters of varying salinities, from brackish to marine (McQuoid and Nordberg 2003); however, it is widely accepted as being predominantly marine (Snoeijs and Vilblaste 1994) where it inhabits the benthos and plankton zones. It has a widespread cosmopolitan preference for marine littoral zones of the Baltic (Snoeijs and Vilblaste 1994) and has been recorded from the Arctic to the tropics. It preserves well in the sediments of water bodies and can be useful as a palaeoindicator species (McQuoid and Nordberg 2003) but can be resuspended into the water column from the benthos by tidal mixing and wind. This, and its broad tolerance, means that detailed interpretation of the presence of this species can be difficult (McQuoid and Nordberg 2003). Commonly, the occurrence of *P. sulcata* in the sediment record has been interpreted as being an indication of high primary production caused by coastal upwelling (McQuoid and Nordberg 2003). McQuoid and Nordberg (2003) suggest that *P. sulcata* may have a competitive advantage in low light conditions as it is often recorded in increased abundances in winter (Gebühr *et al.* 2009) but this may also indicate an increase in the mixing of the benthos. It has also been found to have a negative correlation with salinity levels in the Inlets of British Columbia, showing its preference for estuarine, rather than marine, conditions and Gebühr *et al.* (2009) suggested that high salinity may be a limiting factor for this species. Declining abundances of *P. sulcata* have been attributed to an increase in deposition of fine, organic sediment (Mills *et al.* 2009), and freshwater or increased sediment flux in Chesapeake Bay (Cooper 1995). However, in contrast to the above studies, Zong (1997) reported *P. sulcata* in greater numbers in areas of fine-grained organic-rich sediments.

Thalassiosira lacustris

The Thalassiosirales (from 'thalassic', meaning 'of marine origin') are known to include marine, planktonic, diatom genera, although there are ~12 fresh or brackish water species recognised (Alverson *et al.* 2011; Hasle 1978). Because of the diversity in valve morphology there is much confusion surrounding the taxonomy of the genus *Thalassiosira* (Smucker *et al.* 2008). *Thalassiosira lacustris* was first described in 1856 as being a freshwater species (Hasle and Lange 1989) but this species has since been recorded from both marine and freshwater environments (Hasle and Lange 1989), as reported by Hustedt as early as 1928. Smucker *et al.* (2006) reported the species primarily in marine coastal regions but also from large rivers around the world. It was reported as spreading in North America, first being noted in environments such as coastal areas and large brackish rivers, but Smucker *et al.* (2008) collected it from several inland streams, although it was not recorded in any great abundance, except where moderate to high stream conductivities were also recorded. They concluded that *T. lacustris* can tolerate a wide range of habitats but is most likely to occur in brackish water as opposed to freshwater environs and was found in large numbers only in waters where moderately high conductivity also existed. Snoeijs and Vilblaste (1994) described it as a freshwater species with a brackish water affinity while Soons *et al.* (1997) used it to infer a freshwater zone above a brackish sediment sequence collected in Canterbury, New Zealand. John (1983) observed it in rivers in Western Australia, where he described its habitat preference to be brackish with a salinity range between 2.5 and 15%, although he found it in the lower part of the Swan River estuary, where salinity levels were between 15 and 35%. The optimum electrical conductivity of *T. lacustris* collected from mostly freshwater samples in the Murray River was found to be 936 $\mu S\ cm^{-1}$ (Tibby and Reid 2004) yet Smucker *et al.* (2008) reported that *T. lacustris* did not reach high numbers when the conductivity was <400 or $>2000\ \mu S\ cm^{-1}$.

Truth: Revealing Science behind the Lower Lakes!

A message to the South Australian Government! Your Lower Lakes were not always fresh!

Science can be confounding, and while it's a means for important discoveries, it's also a necessary mechanism to correct mistakes and improve our knowledge to enable us to advance!

Science on occasions has its peer reviewers who relish the opportunity to weed out the flaws. It's the peers who scrutinise each other's research work necessary to correct and improve our knowledge based on advancing research.

Water science is spread over an array of fields and practices. It's a continuing world of observation, experimentation and sampling so vital to improving the records of change with the use of our most precious resource.

There are those qualified in systematic field research study in the science of water, their evaluations sourced by governments, educationalists, entities, reviewers and decision-makers inside and outside of governments and various authorities!

Within these entanglements are strings of documents, data and necessary reference points; on occasions with peer review or even without it! One case in question concerns the values of various scientific data when debating water type in the **South Australian Lower Lakes** and **Goolwa Channel**, located at the southern end of the contentious Murray Darling Basin, in South Australia.

This story concerns basin water usage and necessary lakebed core research into the microscopic world of diatom discovery. It's about sampling and ensuring the correctness of the realised data and its ultimate interpretations. In particular, we follow the advancing science and the recommendations behind freshwater lakes versus the original estuarine conditions for the Lower Lakes end of the Murray Darling Basin system.

Alleged flaws have surfaced in a Lower Lakes science paper! It would be a great loss to the nation if we continue to ignore the perilous state of management and waste of our precious basin freshwater resources.

Looking at this whole water argument and in particular, the continuing calls for more freshwater for the Lower Lakes, we wind the clock back to September 2009 and discuss a (former) South Australian Government department document, openly found on its department's own website today, and through Google.

The document, "***AN ENVIRONMENTAL HISTORY OF THE LOWER LAKES AND THE COORONG,"*** is a Report Commissioned by the former ***Dept. of Environment and Heritage***, as researched and authored by scientists, Jennie Fluin, Deborah Haynes and John Tibby, and released in September 2009.

Nine years on in 2018, this document continued to attract attention and debate among scientists concerning the ultimate research findings into microscopic diatoms from a pre-barrage era. There're alleged concerns about the level of peer review with this document, including the alleged omission of 'diatom proven,' Southern Ocean tidal prism activity in the Lower Lakes and the Goolwa Channel systems, dating back some 7000 years. The document fails to deal with the scientific terminology concerning researched diatom findings from the period and understood today as **tidal prism** occurrences that would very likely thwart a South Australian freshwater only culture, that the Lower Lakes were always fresh in pre-barrage times.

Modern day core sampling of river and lake beds for microscopic diatoms enables concise indications of past and present conditions, including that of ecological character change in these wetland systems over extensive periods. Research results discussed herein, originated back in periods prior to the completion of the barrages in 1940, and according to science, quite possibly as far back as 7000 years.

In the ***Executive Summary*** found on the second page of this non-paginated paper "***AN ENVIRONMENTAL HISTORY OF THE LOWER LAKES AND THE COORONG*** of September 2009***,"*** the summary "***reviews the diatom-based evidence for the history of salinity and pH in Lake Alexandrina and the Coorong. "****The authors state,* ***"Diatoms are a type of aquatic algae that have species compositions highly influenced by salinity and pH of their host waters. In addition, because they build their cell wall from silica, diatoms preserve in sediment."*** The authors also say: ***"Our review for Lake Alexandrina has found there is no evidence in the 7000 year record of substantial marine incursions into Lake Alexandrina,"*** while*…. "There were substantial alterations to the diatom community in Lake Alexandrina following European settlement and particularly after the barrage installations," as found in this unpublished report found on a government website."*

In an earlier, closely duplicated document, ***Palaeolimnological evidence for the independent evolution of neighbouring terminal lakes, the Murray Darling Basin, Australia, 2007*** by Fluin, Gell, Haynes, Tibby and Hancock, the second last paragraph to the left of page 130 says, "*The presence of Thalassio lacustris, Cyclotella striata and Paralia sulcata* ***indicate marine influences*** *at this time. Whereas the same page transferred into the later document,* ***AN ENVIRONMENTAL HISTORY OF THE LOWER LAKES AND COORONG,*** on page six, says, "The presence of *Thalassiosira lacustris, Cyclotella striata and Paral sulcata* ***indicate minor marine influence*** *at this time.* Fluin et al., 2007 said… *the change in diatom community (after 5000 yr BP) is likely to represent a decrease in lake level and* ***increased penetration of seawater****, possibly associated with the variable, dry climate*…, whereupon Fluin et al., 2009 says…"*the change in diatom community is likely to represent a decrease in lake level and* ***increased penetration of more brackish water****, possibly associated with the variable, dry climate…*"

Professor Peter Gell from Victoria's Federation University says, "*we can expect, in a drying climate, that estuarine influence (in the absence of the barrages) would naturally increase from 1850 AD and through into the future. Lake Alexandrina was estuarine from 7000yr BP*

to 1940 CE. Its salinity varied with millennial, multi decadal and shorter climate cycles. It was more tidal near the mouth, less near the river. The barrages drove a permanent change to create an artificially fresh lagoon," he said.

Diatom Scientist, Professor Peter Gell of the ***Water Research Network*** from Victoria's **Federation University** told your writer, "***the diatom record from Lake Alexandrina documents the presence of three diatom taxa*** *(group or family)* ***throughout the record." "These are cosmopolitan, and are known worldwide to inhabit tidal waters." "In a 'Barnett core' I collected, taken in the south of Lake Alexandrina, they constitute 5-25% of the diatoms in any sample,"*** he said.

Prof Gell told how, *"a 'marine incursion' as inferred by authors Fluin, Haynes and Tibby would be recorded as a layer of sediment completely dominated by pelagic, marine diatoms, but this has never been recorded. What is recorded is a reliable representation of estuarine diatoms, decreasing in representation with distance north from the mouth. This is consistent with a* ***tidal prism*** *that attenuates, but reaches the entrance of the River into the Lake," he said.*

Reader Explanation: **Tidal Prism** (Ref: Wikipedia) *The inter-tidal prism volume can be expressed by the relationship: P=H A, where H is the average tidal range and A is the average surface area of the basin.[3] It can also be thought of as the volume of the incoming tide plus the river discharge.[4] Simple tidal prism models stated the relationship of river discharge and inflowing ocean water as Prism=Volume of ocean water coming into an estuary on the flood tide + Volume of river discharge mixing with that ocean water.*

Therefore: Has the character of the Lower Lakes & Coorong wetlands been interpreted incorrectly over time?

According to Scientist, Professor Max Finlayson, "*All too often there is very limited, or no knowledge of the character of the wetland and how it has changed over longer periods than a few years, or at most a generation." "In part, this is because people forget, or do not pass on their knowledge to the next generation (Mackinnon 2013), and in part because researchers and managers all too often have a penchant to (incorrectly) regard old data as out-of-date and irrelevant." "This is where the great value of the palaeocological record comes into play – a source of incredibly valuable information long recognised by the archaeological community but less by the wetland management community." Ref:(Finlayson et al 2016).*

"*As case study examples from a collection of papers from within this Special Issue (below) amply demonstrate, paleoecology can reveal some big surprises about the different past character of wetlands over different time-frames*, according to Gell & Finlayson 2016), and Mackinnon in 2013)."

Reference excerpts above are from:(*CSIRO Publishing, Marine & Freshwater Research* 2016 **Editorial: *Understanding change in the ecological character of internationally important wetlands*,** N.C. Davidson, Institute for Land, Water and Society, Charles Sturt University, Albury NSW 2640, Australia, Previous Deputy Secretary General of Ramsar, *and* Nick Davidson Environmental, Queens House, Wigmore HR6 9UN, UK.

The record of change from southern Lake Alexandrina was presented in Gell et al. (2005) and again in Fluin et al. (2007). "Therein, while it was recognised that the larger lake was strongly influenced by the River, **it also showed evidence of a partial estuarine history."**

The history of the Coorong was reported in Gell and Haynes 2005 and further in Fluin et al., and Krull et al. (2009). These recognised the Coorong as having a strongly tidal history and one largely independent of the River. Ref: Krull, E. Haynes, D. Lamontagne, S. **Gell, P.** McKirdy, D. Hancock, G. McGowan, J. & Smernik, R. (2009), in ***Changes in the chemistry of sedimentary organic matter within the Coorong over space and time. Biogeochemistry, 92: 9-25.***

Briefly: The delivery from the ***Australian Research Council*** (ARC) funded project on the Coorong have consolidated that view (e.g. **Reeves et al., 2015, Gell, 2017), and others have consolidated the partial estuarine history of Lake Alexandrina (Battarbee et al., 2014)."**

And so, in pre-barrage times, the Lower Lakes were occasionally fresh – **but they were also a mix of freshwater and tidal prism ocean water, becoming estuarine!**

The long-term history of the Coorong and Lower Lakes has become critical in the on-going case to justify the transfer of **Murray Darling Basin** water to South Australia's Lower Lakes. History also provides a baseline to support, or perhaps challenge today, the current ecological character descriptions identified under the ***Ramsar*** listing.

However, the September 2009 report (***AN ENVIRONMENTAL HISTORY OF THE LOWER LAKES AND THE COORONG***), authored by Fluin, Tibby and Haynes remains on the State Government Department website. It offers contrasting interpretations that there was no evidence for a marine incursion over the last 7000 years.

According to Professor Peter Gell, "while this remains true as a 'marine incursion' would invoke a relative sea level rise, but it doesn't discount the long-term prevalence of strong **tidal prism** activity in Lake Alexandrina," he said.

This poses a question of whether PhD qualified physical geographers would inadvertently confuse marine incursion for **tidal prism**?

It's equally perplexing that the document does not acknowledge the ***University of Adelaide*** within its contents, where it's alleged; most of this work was carried out?

Why then did the authors not see to the acknowledgement of funding from the ***Australian Research Council*** and to Prof. Gell, who himself was also not acknowledged or for that matter, even consulted? There's a difference in being referenced and being consulted!

"*There're questions on whether the senior author at the time the report was lodged, was an independent academic, under the employ (or Commission) of the managing government department. If this was so, why does the managing government department refer to an undated, 'internal' report that has allegedly not undergone peer review, over what are possibly many publications since this period, that have indeed, undergone peer review*," according to Professor Gell?

Looking at another perspective on another connected subject today, it's also about the quality of freshwater reaching the Coorong!

During July 2017, details were released concerning the quality of water throughout all basin rivers and the Coorong, where extensive field research investigations across most

basin rivers have discovered finely granulated sedimentation in suspension. This blocks sunlight from penetrating through the upper water column to riverbeds across most basin systems. This sedimentation condition is to the detriment of an array of aquatic biota below, including important aquatic vegetation, fish, molluscs and crustacean, as well as the necessary quality of fresh water within the basin river systems. It affects water quality for many, including growers and basin communities.

These likely place future water procurement expectations concerning the health of our water resources across the basin, under an additional but necessary spotlight!

It also brings back into focus what is considered a right by the MDBA to create a wider 'greenbelt' beyond the natural river channels by processes involving overbank flooding. Practising this to actively water vegetation that's ordinarily, and naturally watered by rainfall precipitation. At any time and any level, this practice is damaging and costly!

Once again though, scientific history has been discarded! ***"In summary, the current operating system for the Lower Lakes and Murray Mouth is not sustainable with continued significant environmental degradation expected,"*** the former Murray Darling Basin Commission advised back in the year 2000.

Meanwhile, Palaeoecologist, Professor Peter Gell from Ballarat Federation University, in a recent interview with ***The Land*** newspaper told of "*Serious turbidity from increased sedimentation particulate in mid-river wetlands and even in the Coorong is now scientifically tested and acknowledged. The decline came to the attention of scientists from core sampling that exposed 7000 years of fine, settling materials such as sediment on to the submerged landfall. These findings are the results of several decades of core sampling and other investigative work,"* according to Professor Peter Gell.

"*In the Coorong the sediments are coarse shelly marl prior to the establishment of the barrages, after which fine, organic muds accumulate. Above, many wetlands accumulate sediments only after regulation and, before then, were likely dry enough for the sediments to blow away. So, their natural wetting regime is irregular. Now, they are tied to a stable, wet system and continuous sediment accumulation is the new normal. Scarily, this is occurring at 2-5cm/yr and so these depressions are filling up quickly with mud, and are so turbid, there is not enough sunlight reaching the bottom for plants to grow actively. Frequent watering of these sites with turbid water is unlikely to stimulate plant growth and is contributing to net sediment accumulation,*" he said.

According to Prof Gell, we should explore the options for Lake Alexandrina for the next big drought. He questions whether we're to aerially release mulch, while calling for river flows when there are none, or to allow the sea in and protect freshwater habitats such as the Currency Creek and Finniss River deltas with low barrage barriers.

With a wide focus on water quality, all plants and other organisms rely on photosynthesis to synthesize nutrients from water. Sedimentation affected wetlands include those that may already have questionable ***Ramsar*** connections, including those of the Lower Lakes and Coorong region. Widespread particulate in the upper water column could badly disrupt or even destroy water quality across the food bowl; throughout all of the Murray Darling Basin river systems.

Diatom species-water calibration through core sampling for historic fossil taxa, is practiced from estuarine and freshwater environments across Australia. It's these important records today that will likely play a major role in future decision-making processes for our rivers and the Lower Lakes and Coorong.

Professor Gell commenced specialised diatom and environmental study in France back in 1989, for his PhD. Literature from the Federation University reveals, *"Prof Gell is a palaeoecologist who examines change in condition of wetlands and culturally relevant timelines. He has a particular interest in contributing to a better understanding of natural ecological character under the* ***Ramsar Convention****. He specialises in diatoms as indicators of present, and past, river and lake condition, particularly in coastal systems across Australia's Murray Darling Basin.*

In an intriguing ***1902-03 Inter-State Royal Commission Report on the River Murray***, details include conditions back then within the Murray Mouth and Lower Lakes. *"One effect of a deep entrance channel would be to increase the saltiness of the lakes, which, after a strong north-west or westerly gale,* ***are brackish****;* ***the salt water being forced up channels as far as Wellington.***" Further, *"When the winds shift to the south-east it is again blown out of the lake,* ***a greater quantity running out under these circumstances than during any river flood."*** The Master of a trading boat at the time is quoted as saying *"he had known the water of the lakes as salt in past years."*

In a ***"River Murray – Darling to Sea Expert Technical Workshop 1-3 July 2009,"*** Dr in *Ecology****, Kerri Muller*** *(*of *Kerry Muller NRM)* ***agrees the system formed some 7000 years ago!*** In her 2009 workshop conclusion she said, "*The previous 'healthy' estuary of the Coorong is gone as are keystone plants – it is now effectively an aquatic desert."* During the same workshop, Flinders University modelling experts, Rebecca Lester and Peter Fairwheather, with their modelling for ***Current & Future Condition of the Coorong,*** said in their conclusion, "***there is no substitute for barrage flows. Climate change does not have to destroy the Coorong ecosystems- extraction levels play a much bigger role. Additional freshwater is urgently needed for the system – the River Murray should be the major source,"*** they said.

Meanwhile the former Department of Environment and Heritage (known as DEH then and followed by DEWNR today), through its scientist, Russell Seaman told the workshop how "the expert community, the ***River Murray-Darling to Sea*** is a unique 'environmental unit' that is different to its parent rivers, the Darling and the remainder of the Murray, and therefore warranting of ecological community status in a national context." The following points were acknowledged, including, *"deep limestone strata and saline groundwater (****and marine fossils in the river cliffs****) reflect* ***marine incursions over the last 20 million years. "****Fish fauna shows strong* ***marine/estuarine*** *influence, owing to the regions proximity to the river mouth,"* Seaman wrote.

For those who can remember pre-barrage times and the state of the Lower Lakes and Coorong back then, on reaching the Murray Mouth estuary, river water naturally competed with a more powerful **Great Southern Ocean** and its extensive tides. Tides that ebbed and flowed at sea, with coastal ocean flows entering the Murray Mouth and into the Lower Lakes at various strengths depending on tidal height and flow, often assisted by prevailing ocean wind at the time. Meanwhile, freshwater flowing downstream towards the mouth, often competed with off-shore prevailing winds and squalls from the Southern

Ocean with powerful ocean tidal influences often pushing freshwater well back into the lakes system in a stratified form that eventually mix to become estuarine.

In affect, during incoming tidal periods, the powerful **Great Southern Ocean** regularly reversed out-going freshwater river flows, back through the mouth and the channels, and back into Lake Alexandrina. On occasions during pre-barrage times, these ocean-pushed flows entered the lower reaches of the river where ocean and by now estuarine water had little competition before the introduction of various river locks and weirs. The power of ocean tides in this region is better understood when one considers its force of flow in pre-barrage times, before locks and weirs when ocean water flowed past the north-eastern entry point below Wellington where the Murray River spills into Lake Alexandrina, some 45 km north of where the Murray Mouth spills into the ocean today.

Even since the completion of the barrages, ocean water assisted by prevailing offshore ocean winds and tides are often strong enough to reverse out-flowing river water, pushing freshwater back through opened barrage gates towards the top of Lake Alexandrina.

This was also not unusual in **post-barrage times**, particularly when the Goolwa barrage operators struggle to crane the concrete stop logs back into a closed position when sudden offshore ocean squalls and storms hit the southern coast. These occurrences are meticulously recorded through real-time electronic telemetry beacon probes for salinity (ECu) variances with subsequent plot readings transferred to paper for future reference.

Major Commercial Fishery in Lake Alexandrina.

In further support of an estuarine-featured Lower Lakes in pre-barrage times, from the late 1890's right up to 1940 when the final barrage, the Goolwa Barrage was completed, there were several flourishing commercial fisheries within Lake Alexandrina and the Goolwa Channel. These waters were commercially important for regular fish supplies to South Australian and Victorian markets.

According to details from the SA newspaper, ***The Advertiser*** of October 13th, 1933, it was the day before a Barrage Inquiry with the *Public Works Evidence Committee* when a meeting was arranged to meet with commercial fishers and residents at Milang, on the western side of Lake Alexandrina. To bolster their case, the commercial fishermen put on what was considered at the time to be the best fishing equipment display in the Commonwealth.

They had nine fishing cutters (motor/sail with lug-rigged mainsail), some up to 40 feet long, anchored close to the Milang jetty while seven, long net drying lines located on the shoreline of the big lake had hundreds of nets draped over top to dry. In a further show of strength, they had at least 200 other nets tossed over the shore end of the Milang jetty railing. Some 30 dinghies and fisher motor lorries were used to transport the catch, were clearly visible close by!

The (Adelaide) *Advertiser 1931 -1954 reported how the Public Works Standing Committee Chief Inspector of Fisheries, Mr W.D. Bruce said, "there were about 40 - 44 men at* ***Goolwa*** *dependent on fishing for their sole livelihood, 20-30 at* ***Milang*** *and four at* ***Langhorne Creek*** *with about 4 at (*a place known then as) ***Naming****."*

They strongly argued, the *"Barrages would mean the end of the fishing industry here, according leading fishers, Messrs, Walter and John Woodrow*," from the famous Woodrow fishing family. The barrages *"would rob an average of 25 licensed fishermen of their living as well as a few young men who help their fathers with the nets,"* they said.

"As evidenced to the importance of fishing out from Milang in that era*, 272 cases of fish were sent to Adelaide from the local railway station last month, "* the newspaper report said.

Today, Victor Woodrow, born in 1930, is a surviving family member of the five famous Woodrow commercial fishing families, and a he's stickler for keeping an extensive bundle of historic papers and photos concerning the commercial Mulloway and Murray Cod fishery across the top of Lake Alexandrina. Mr Woodrow still recalls those rare days when the five Woodrow commercial fisher brothers including his father, sat around the table, swapping their fishing prowess, their catch secrets and successes.

Many of the Woodrow men of the era started their fishing weeks within the lakes, for some in site of **Pomanda Island** where many stayed over, during a period of ten years or more in the old stone cottage with a thatched roof, located close to where the Murray River enters Lake Alexandrina, just below Wellington on the Murray River.

These were serious commercial gillnet fishers working with large numbers of nets for catching Mulloway near the top of the lake, providing huge quantities of South Australia's fresh fish supplies. They also long-lined for Murray Cod within the same area by taste-testing the water drawn up from the bottom of the lake from a small bottle, in one case weighted with an old tomahawk head and a cork retrieval arrangement, allowing the capture of a lakes water for taste sampling.

Their estuarine caught mulloway were, in their language '***shoulder height length***,' and often up to 90lbs(40.8 kg) heavy – fully dressed.'

Their taste testing keenly established the whereabouts of fresh and estuarine water stratification in the same area in order to establish the whereabouts of large mulloway and Murray Cod lurking nearby. **Tidal prisms** spoken of today, were an un-known science during their era, although its clear in today's world that a tidal prism fittingly describes a similar measure of their notion of freshwater and estuarine water stratification known to fishers back in those days. Explorer, Captain Charles Sturt discovered the very same thing when his crew rowed him into the upper Lower Lakes.

Tidal Prism activity in the Lower Lakes are officially recorded today by 'real-time' telemetry beacons, each with four or five electronic probes reaching into the depths of water below, where one single probe on each beacon registers EC'u (electrical conductivity units) crucial to recording ocean ingress or **tidal prism** and other saline conditions at the time, that are transmitted in 'real time' to a central government database. Those that follow these plot results from the in-water probes will have recorded tidal prism ingress high into Lake Alexandrina, towards Pomanda at various times of the year.

History reveals in pre-barrage times how estuarine water actually reached Swan Reach in the Riverland, and other river reaches further downstream where marine species

including mammals were seen. Mullet were caught in Mannum! A Dolphin visited Murray Bridge and a Shark was seen in Tailem Bend.

However, estuarine water in the lakes didn't suit every purpose!

"It was March 5th, 1903 when Mr W.P. Dunk sank a 78 feet bore at the end of the Milang jetty. He did this so that steamers plying the lakes and the river could secure reliable freshwater for their boilers. It was also reported, **"In pre-barrage times Lake Alexandrina was periodically quite salty."** Many steamers trans versed the lakes and the Murray River. One necessary resource concerned the continual availability of freshwater only for their boilers. Estuarine water would have dramatically reduced the life of an expensive ship boiler!

There're questions of water management under successive South Australian State Government's and their leaders including the former Premier Mike Rann(March 2002 to October 2011) followed by the Premiership period of Jay Weatherill. They campaigned for more freshwater for the Lower Lakes, based on a false premise and a plethora of published documents and brochures that the Lower Lakes were always, only freshwater lakes.

As leaders, they would have, or should have been briefed by their department. They certainly created interest in sections of the South Australian media. In two examples, Editorial excerpts from the Adelaide *Advertiser* claim its paper spearheaded the "***I Love Murray"*** Campaign during the destructive Millennium drought. On the 8th August 2017, in *The Advertiser* newspapers ***"River System Swindle***" lift out, when the then South Australian Premier, joined by his Water Minister and Senators from four parties called for a Judicial Inquiry into the river water theft scandal as portrayed by the ABC's Four Corners programme.

From a basin-wide water sharing perspective, the Murray Darling Basin Authority (MDBA) continues to produce a plethora of management documents, occasionally to the distaste of growers due to questionable modelling anomalies. With the likelihood of climate change producing less water for the catchments, landowner-food producers across the basin are crying out for inevitable management change!

To set the record straight, irrigators throughout the basin generally only ever receive their agreed allocation, and more often than not, these sustainable diversion limits (SDL's) or allocations are saved to create up to three watering's on the same crops via private reservoir storage and careful water reuse management.

Albeit, grower/irrigators across the basin hold grave concern due to appalling management intellect when it comes to water sharing for Australia's food security. They're again facing water supply cutbacks to SDL entitlements to satisfy an authority that continues on with its greening of basin floodplains well beyond the riverbanks in areas where natural rain precipitation would ordinarily water that same vegetation. **Growers hold grave concerns about the immense losses of freshwater in the Lower Lakes.**

The main debate today, includes a recent decision by the Murray Darling Basin Authority (MDBA) to claw back 605GL from irrigator water efficiency measures. This follows the South Australian Government continuing to argue for an extra 450GL through its (then)

Water Minister Ian Hunter. A quandary exists for some at this point as to whether the Basin Ministers actually made the final choice of these clawback amounts or whether the Authority muscled its way over the debating table in pursuance of satisfying its own, wider environmental watering outcomes.

It was clearly stated by the former Deputy Prime Minister, Barnaby Joyce late in 2016 when he said that it would be impossible to send an additional 450GL of water downstream due to river constraints with the likelihood of property damage on the way.
Interestingly, it was made clear in letters of 12th November 2015 from the Prime Minister's Office and 27 May 2016 from the ***Commonwealth Environmental Water Holder*** that overbank flooding of private properties would not occur without written approval to do so!

Most agree how change can lead to progress, and many want that for our dwindling food-producing basin! Proposals for change in water management that will enable water savings across the basin have surfaced from time to time from various sources. The majority of these proposals have large water savings and improved food production in mind.

One solution offers benefits across the whole Murray Darling Basin, including extensive benefits from the much-maligned estuarine end in South Australia. Details of this were written and distributed widely across the basin.

They include a 2,700GL/yr. freshwater saving from the Lower Lakes, for upstream irrigators and a 150GL flush of the Murray Mouth in a single outgoing tidal period, as often as necessary! The same solution provides for the return of a huge mulloway fishery known to the region in pre-barrage times. This work was never officially acknowledged even though it also reached the MDBA and the Prime Ministers office in recent years.

As frustrating as this is, basin governments and those within the MDBA continually refuse to acknowledge proposals other than from their own internal sources.

Interestingly, the ***Australian Research Council Centre of Excellence for Environmental Decisions, CEED's "****Professor Hugh Possingham says that citizen scientists not only gain a good education about Australia and its biota, but can also make an important contribution to science and hence to more effective national conservation policy."*

Among these citizen scientists are the retired professionals who steadfastly remain at the coalface today. It's their work born from experience, and championed out of their own pockets that watch over the work, including that of the Murray Darling Basin Authority and participating state governments and agencies. It's these same retired professionals that diligently correct official work, and where possible, share newfound corrections and information with thousands of irrigator growers, councils, communities and numerous individuals.

Selective Murray Darling Basin Authority media statements and those from the SA state government regularly include calls for more freshwater for the Lower Lakes and to clear the Murray Mouth. These calls generally include the subject of removing 2 million tonnes of salt from the basin system to be flushed through the Murray Mouth.

In early 2017, during questionable floods across the basin, it was officially but grudgingly recognised by the MDBA that 95 gigalitres/day of freshwater crossing the SA border was not sufficient to clear the Murray Mouth. The expensive consequence was to continually clear the Murray Mouth by using two dredges.

Insofar as exhausting salt from the system, a retired South Australian scientist, Ian Rowan BSc with Hons, successfully negotiated copies of the official calculus behind the 2 million tonnes of salt theory from the SA department formally known as *Dept. Environment Water and Natural Resources* (DEWNR). Rowan eventually described their figures as myth! For example, during the 2011-12 and 2012-13 water years, flows were still moderately high at an average of 7,000GL/yr and the salinity remained at about 500 ECu (Electrical Conductivity units) with an estimated average annual salt export of 1.8 million tonnes.

"*During the 2013-14 to 2015-16 water years, flows were very low (1,800GL down to 700 GL/yr) when an estimated annual average salt export was only 0.5 million tonnes. Lake salinity gradually rose to 900 ECu over this 3-year period but was still below the official 1000 ECu (salinity level) thresh-hold, set under the MDBA's Basin Plan*," he said.

His conclusion was that the 2 million tonnes of salt catchcry was a myth and even with low flows and salt export only at about 0.5 million tonnes per year, salinities will likely remain within acceptable levels for many years; that's providing the expensive river mouth dredging exercise continues**.** An attachment supplied herein, contains the most recent work on salt issues by Ian Rowan BSc Hon.

Climate forecasts increasingly dictate less rainfall over the eastern state catchments, potentially realising a possible future with less water availability from dwindling supplies for human consumption and for basin growers, while marginally satisfying at great cost, the SA state government with fresh water for its Lower Lakes and river mouth.

It's about total basin water capture against usage! **The combined overall capacity of mountain storages for the basin is 22,255GL. At 2nd May, 2018, the storages combined, contained 10,793GL or (48%) only. The Lower Lakes, Murray Mouth and the Goolwa Channel alone, use approximately 4,500GL plus/yr. during an average temperature year when evaporation levels are reduced.**

There're increasing calls for change in the way we use river water across all basin states, with an emphasis on wasted freshwater in the Lower Lakes and Murray Mouth region! Simply; due to reduced rainfall, we don't have enough to supply the growers and the Lower Lakes at the same time.

Of significant concern is South Australia's average 'high security water' usage and waste from the lakes, through clearing the mouth, and to evaporation and seepage! Based on SA tender prices for water from the Murray River, with a minimum usage of 4,500GL/year throughout the Lower Lakes, the Goolwa Channel and for clearing the river mouth, this water within the lakes and channel regions only, is valued at about $7.53 billion dollars per year. This figure pales when comparing the Commonwealth purchase of 28 gigalitres for $78.89 million dollars (or $2,820/ML) from Queensland's Condamine-Balonne system during August 2017.

These figures must surely be the neon for an awakening targeted at politicians and their internal government authorities, scientists and advisers who either refuse to listen, or

imply they're listening when in fact they're not. They're strongly urged to no longer sideline the society they serve when it comes to Australia's all-important food security!

These situations are often relative to '*Theory Induced Blindness*,' where rational science and community thinking are set aside for political ideology.

The acclaimed book by author, the late ***"Rachel Carson did more than challenge science. She exposed these experts to public scrutiny, and made it clear at best, they had not done their homework, and at worst they had withheld the truth."***

Either way, Carson was right in her quest and tenacity to dig deep! Therefore, should we hold back and not seek truth from science? Under the circumstances, 'if it looks wrong' its doubtful we'd hold back!

So, where's the truth with the Murray Darling Basin and its controversial Lower Lakes and Coorong? It's at this end of system where Basin Rivers terminate their extensive journey into an otherwise historic estuarine condition. All the while, the new Government of South Australia has yet to show its hand with the continuous fresh river water only supplies for these lakes versus the option to return the cost-free ocean into the lakes system and reap the benefits.

This question has historically positioned itself as a long-term line in the sand; to the detriment of the whole basin and its irrigator growers and the environment. But there is more to this basin wide story!

From basin-wide community perspectives, it's not unusual to participate in discussions about the **Lower Lakes** with opposing viewpoints about management policies for these environments. For many locals from the four lakeside towns, there're deep community concerns about the likelihood of further drought, again exposing dried out, acid-laden lakebeds as witnessed during the Millennium drought.

Dredging the Murray Mouth has cost taxpayers multiple millions of dollars since 2002, and with a second dredge onsite, it continues with the realisation that billions of dollars of otherwise valuable fresh river water has been allowed to flow through the river mouth during countless, failed attempts to clear it. The financial returns by using some of this valuable water back upstream in food production would be enormous.

Nonetheless, fresh water only enthusiasts and some authority scientists continually hold the view that the **Lower Lakes** were always fresh. Whether this stance will continue may only be gauged from daily media snapshots.

Of interest, Lake Alexandrina alone contains an estimated 500 million tonnes of dangerous acid bearing soils in its lakebed. It's imperative that lakebeds are covered with water to hold back acid mobilisation. Ocean water mixed to an estuarine condition within built up areas will clearly counter any concerns.

In one example when an acid flow occurred in Trinity Bay Inlet near Cairns in the late 70's when a new development exposed acid laden soils to oxygen. Reports of mobilised sulphuric acid pouring into the ocean at the rate equal to a small swimming pool/day, that took 23 years to stem. An estimated 120,000 tonnes of sulphuric acid reached the Pacific

Ocean. Flows were gradually halted following tests using slow distribution of ocean water across the site.

The Murray Darling Basin Authority (MDBA) also holds firm with a fresh only standpoint, as found in a plethora of documents. In one MDBA example, in its 2011 "***All about the barrages***" Fact Sheet, it says on page 2, ***"There are a variety of views on what the Lower Lakes were like before European settlement;*** (before the barrages) ***however, evidence shows that the lakes were predominately fresh. This is because most of the time, flows of freshwater down the River Murray would have been sufficient to fill the lakes and keep seawater from creeping in,"*** **it said.**

Despite the best of science quality, on the same page it says: ***Microscopic analysis of single-celled algae (Diatoms) also provides evidence that in the 7,000 years they were formed, the Lower Lakes would have been mainly fresh with rare seawater inflows."***

On page 3, under subheading ***"Why were the barrages built?*** The MDBA says, ***"From the 1880's the South Australian Government was concerned about maintaining freshwater supplies for stock, irrigation and domestic purposes for settlements along the lower Murray and around the Lower Lakes."***

"There was concern that due to increasing use of water all along the river, flows would not be sufficient to keep the lakes fresh*," it said.*

The S.A. Government agency, Dept. Environment & Water (DEW today), in its ***Murray Futures Fact Sheet***, "***A freshwater future for the Lower Lakes***"(undated but assumed) pre-2012 due to agency name change) says the following:
At a glance*:*

- *The Lower Lakes have been mostly fresh water for 7000 years.*
- *Even in a future dry climate, the lakes are likely to remain mostly fresh water.*
- *The South Australian Government is working to secure a healthy, fresh water future for the lakes.*
- *The Murray-Darling Basin Plan will increase the amount of fresh water to the environment.*
- *Sea Level rise is not an immediate threat to the Lakes.*

In "***A Fresh water history of the Lower Lakes***" it says, "*The Lower Lakes have mostly contained fresh water for 7000 years, only occasionally becoming estuarine for a short time."*

In a department statement under, ***"fossils to reveal the regions past***," it says in part: ***Diatoms found in 7000 years of sediments indicate the majority of Lake Alexandrina was fresh water in all years,"*** the government said***.***

Of interest on ***DEW'***s 2nd page: ***"Sea Level rise is not seen as an immediate threat to the Lower Lakes,"*** as reported in the *Murray Futures Lower Lakes & Coorong Fact sheet* reports. Conversely, another department holds 2050 as a deadline for ocean water ingress over the barrages!

With sea level rise assisted by southerly busters, the Great Southern Ocean often enters through ruptured barrages and through known upwellings from under the sand hills separating the Coorong from the ocean. These are regular events during winter months, upside of the Goolwa Barrage, in lakeside Goolwa. Electronic plot readings also pinpoint these **tidal prisms** into Lake Alexandrina in real time, as do thousands of hungry seabirds that immediately congregate in the Goolwa Channel above the Hindmarsh Island Bridge, to feed on sprat marine fish or newly affected freshwater species caught in a changing water stratification system of freshwater mixing with tidal ocean prism's.

In June 2010, the former SA Department of Environment & Heritage produced its *Murray Futures* document, "***Securing the future"*** – a *Long term plan for the Coorong, Lower Lakes and Murray Mouth* of some 168 pages.

> On page 80, below its subheading, it asks? ***"Is a freshwater future possible?*** It then says, ***"Drawing from the best available CSIRO information, it is reasonable to base the plan for the Lower Lakes around freshwater. The development of the Basin Plan is a most significant initiative contributing to delivering an adequate and end-of-system freshwater flow."***

Comments from four mainstream growers/entities across the MDBA.

CE Ray Stubbs manages the **Ramroc Group of 13 River councils**.

RAMROC and its Member Councils have been extremely concerned that critical issues associated with improved management of the Lower Lakes, Coorong and Murray Mouth have consistently been "off the table" by the Commonwealth and South Australian Governments, both during and following the development and implementation of the Murray Darling Basin Plan.

CE, Ray Stubbs

Darren De Bortoli.

The Murray Darling Basin is a highly variable river system ranging from severe droughts such as 2006 when all the rivers in the basin would have been dry. The severity of the variability was seen in the flooding rains such as those in 1956 when 6 times the combined current storages of all the dams, locks and reservoirs flooded down the system. It is sheer lunacy to send large volumes of water out to sea when we could be only 6 months away from the next drought, a fact not lost on the International Water community and critics such as the late Professor Briscoe from Harvard University. With a proper natural resource management approach substantial volumes of water can be returned back to rural communities where the environment would be better off and the ecological and environmental devastation associated with large " environmental " flows seen in the past would be substantially mitigated.

Darren De Bortoli

De Bortoli Wines Pty. Limited

Jan Beer,

Major Goulburn River Grower and experienced grower Representative!

The Murray Darling Basin Authority has based the Sustainable Diversion Limits for the MDB Plan on 114 years of historical climate and inflow data despite the fact that this data is out-dated and now irrelevant., as best available scientific evidence states that we are now in a drying climate cycle where a 15% reduction in annual flow to the Murray Darling Basin system is forecast. The proposed environmental flow requirements for specified icon sites and the Lower lakes & Coorong is therefore simply not viable nor achievable and will create massive socio- economic impacts.

Jan Beer

John Lolicato

This or any future plan for the Basin can only succeed if the issues are addressed at the lower end of the system. Issues such as:

- The Lower Lakes are the single biggest losses of fresh water from the basin
- Better operation and management of the Lower Lakes and the Barrages
- Re-directing the south/east drains back into the southern Coorong.

An example of the unrealistic target of the BP is the requirement to reach flows of 60,000 to 80,ooo ML at the SA border. The recent 2016 flood proved to achieve this figure (to 95GL/day) with tens of thousands of hectares of food-growing country upstream was flooded causing massive damage.

As the E water targets and demand shift further downstream, the mid section of the Murray (Barmah choke) and Edward River are beginning to collapse due to attempting to maintain high flows through to the end of system.
It is essential that the MDBA adopt better management and operation of the Barrages and Lower Lakes. Suggestions and realistic solutions have been compiled in a document called "A Better Way" by Ken Jury

John & Kerri Lolicato

Further References:

Ref: Salt ECu, (Scientist I. Rowan BSc Hons).
Ref: (http://scinews.com.au/releases/713/view)
Ref:(*A Better Way for the Murray Darling Basin*, K. Jury. 2016)
(Ref; hard-copy plot readings monitored by the undersigned and Ian Rowan BSc Hons of Goolwa SA). Contact .
(website: *LakesNeedWater* – "Case for Seawater").
Ref:(From recent interview's with Victor Woodrow by Ken Jury of Goolwa) Refer K Jury.
Ref:(P.Scott interview, *The Land Newspaper*, Edition 6th July 2017).
Ref*:**(**River Murray Barrages Environmental Flows,* page ix, ***MDBC*** 2000).
Ref:(Peter Gell –Publications/conferences, Research-Federation University Australia).
Ref:(DEH. ***Lower Lakes & Coorong Big Picture Fact Sheet****)* dated early 2009.

Note to Readers:
To assist in determinations of the **Lower Lakes** story, it is also recommended they call up a pod cast of a radio interview of two key scientists mentioned in the above story. Interviewed separately on the same subject was Dr John Tibby, followed by Professor Peter Gell from Federation University in Victoria. Their interviews were broadcast separately on the same day, from the same program hosted by retired science teacher, Trevor Harden of SA, in 2014 on his radio show .
Recorded sessions were completed on community radio 5efm in Victor Harbor on the south coast of South Australia. The guest interviewee's were interviewed on the very same subject involving the comprehensive diatom research investigations and findings in South Australia's Lower Lakes. For many, the answers are polls apart!

Go to:

www.makingsenseradio.com

Making Sense Special 2 – Science? – 20/6/14

The Diatom evidence and the Lower Lakes – same evidence – two interpretations. Dr John Tibby **and** Professor Peter Gell **from 5efm's Making Sense 76 (19/11/13) – You be the judge?**

Footnote:
Various documents and pictorial details within, together with a single radio show Podcast were gathered and collated by the undersigned, while the use of the radio podcast interviews is kindly approved by the Producer/presenter of <Making SenseRadio.com>, Trevor Harden to assist in the development of science!

The undersigned welcomes inquiries regarding any additional information that may be required by media representatives. Contact: or by

Ken Jury, Senior Investigative Journalist (Marine & Aquatic Ecology).

South Australia. Last Updated 10th May, 2018.

Future demands Barrages must remain in p

The completion of the **Federal *Senate Select Committee on the Murray-Darling Basin Plan, Refreshing the Plan*** document ('wrap' paper) of March 2016 includes 31 Senate Committee recommendations. In its Executive Summary, the Senate Committee considers the implementation of the Plan requires greater effort to minimise its negative impacts.

For example, in its **Recommendation 14**, (3.284) the committee recommend the government undertake cost-benefit analyses of the following options for adapting the management of the Lower Lakes and Coorong, and their social economic and environmental impacts throughout the basin, under these dot points:

- *removing the barrages;*
- *removing some of the barrages;*
- *modifying some of the barrages (such as Tauwitcherie and Mundoo);*
- *allowing the ingress of salt water into the Lower Lakes during periods of low flow;*
- *and investigating the construction of an additional lock at a location above Lake Alexandrina, such as near Wellington, SA either in concert with the above options or as a single change.*

In further recommendations: ***(3.285),*** the Committee says, ***"Should such an analysis indicate that one or more of these leads to more positive social economic and environmental outcomes than the current basin plan, the committee recommends the Plan be amended accordingly."***

The five dot points above are representative of some of the proposals put forward by various Senate Inquiry witnesses, through inquiry presentations, written submissions and other supporting documents gathered during the course of nine separate senate inquiries across the Murray Darling Basin.

By seriously investigating the first two dot-point subjects, we find extensive downsides and many likely impacts on adjacent towns by removing the barrages! These towns include **Goolwa**, **Meningie**, **Milang** and **Clayton**.

During the Millennium drought and to assist lakeside industries, freshwater feeder pipes were introduced down both sides of the Lower Lakes from the Murray River near Tailem Bend. Currently, some lakeside irrigation continues using Lower Lakes water, depending on type of use and levels of salinity at the time.

The established lakes edge environment and infrastructure adjacent to these towns would suffer major losses when the water subsides following the removal of the barrages. The barrage barriers ordinarily maintain lakes and channel water at an approximate Australian Height Datum of AHD 0.75 above sea level

since they were completed in 1940. By controlling water levels located upstream of the barrages to Lock One; the lakes and channel surface water levels would ordinarily be maintained at a satisfactory levels to create reasonable surface water alignment with extensive, purposely built infrastructure including marinas, landings, jetties, pumps and various thoroughfares throughout the surrounding edges of the lakes and channels bordering the 840 sq km Lower Lakes system.

Removing the barrages would drastically affect both private and commercial property amenity and vessel passage from these towns. Most vessel movements located on the upside of the former barrages would be either completely neutralised or extremely limited when wanting to reach and access the Coorong. Creating a natural (barrage-free) estuary on the edge of these towns today, would not be acceptable to the residents and industry alike, and to countless thousands of tourism visitors who frequent each of the locations for respite, and recreation including numerous water activities.

Wind seiche is regular in this region where surface levels can vary up to a half metre or more during extremely windy conditions. During these periods in post-barrage times, it's not unusual to find the barrages closed to assist in limiting the impact. However, during tidal ebb and flow, without the barrages, ocean water would quickly penetrate into the Lower Lakes system, and at the turn of the tides, it would just as quickly flow back out, through the Murray Mouth. Wind seiche would on occasions add to or lower tidal ebb and flow levels.

Without the barrages in a natural tidal system, the ebb and flow of the tides in this region would conceivably last all day or all night, or part thereof which would repeatedly remove the amenity or useful water lapping features of the surrounding region where receding tides would expose putrid, acid bearing muds and leave vessels stranded for many hours until the next tidal period. Conceivably, this situation may extend upstream for 274km to Lock One at Blanchetown unless a proposed Lock Zero is built below Tailem Bend prior to dismantling the barrages. Without the barrages and Lock Zero, the affects would also be noticeable upstream in lower Murray River regional river towns including those associated with managing the water intake pipes for Adelaide's reservoir's, located at Swan Reach, Mannum and Murray Bridge, below Lock One at Blanchetown.

Given we suffered during the disastrous Millennium drought, isn't it time to seriously think about the basin holistically, about forecasts of less rainfall into the storages resulting in less for taking from basin rivers, with the dire need to protect Australia's food security, and why many have a false expectation that we have an endless river water supply that will naturally flow 2500km downriver to fill every expectation when it comes to fresh river water only for the Lower Lakes and to clear the Murray Mouth!

As a result of low rainfall over the catchments and reduced water levels in the whole of basin storages (Ref attached MDBA data, Whole of Basin Storage figures

saved by the author Oct 2012-2016), revealing reduced rainfall and river flows. While already witnessing visible signs of sea-level rise!).

The barrages most certainly should be retained and improved.

They'll become increasingly important in limiting the impacts from future severe weather conditions and sea level rise. Those that advocate the removal of the barrages have obviously not studied the current and future implications of their proposal. Conversely, many deem this 'remove the barrages' proposal lacking in substance from underestimating the Lower Lakes region and the wider basin area including the far-away mountain storages. Of paramount importance to reaching any conclusions are the subjects of future climatic conditions, likely reduced rain runoff in the catchments, less water for food production and the environment and reduced future levels of downstream water availability from the mountain storages, some 2,500 km upstream. The distance alone between the mountain storages and the Murray estuary place major hurdles with river water supplies over long distances with major losses estimated up to 60% volume levels from evaporation and seepage loss alone is possible, (ref: former MDBC).

In a barrage removal scenario without Lock Zero, towns in the lower Murray River reaches up to Lock One at Blanchetown would also face dire consequences of a continuous ebb and flow tidal existence, whereby receding ocean water, would create an unsightly scene of exposed mud and debris notwithstanding inconvenience to river towns as well as the four towns fronting the Lower Lakes. River bank slumping as occurred in the lower Murray River during the drought would occur again and further destroy property close to the river edge. The loss of amenity and inconvenience to various boating organisations, including the historically famous ***Goolwa Regatta Yacht Club*** and the ***Goolwa Aquatic Club,*** its sailing craft, powerboats, canoe and kayak activities would be enormous. All would be drastically if not completely compromised in a tidal only Lower Lakes estuarine system.

For lakes towns, all have planned and developed substantial surrounding infrastructure designed to take advantage of the beauty of the attached waterways that bring property safety, delightful attractiveness and community usefulness throughout the whole lakes district.

The four towns in the region are also holiday destinations for multiple thousands and for full-time residents who have chosen these idyllic places to live and enjoy the benefits of what this unique setting naturally offers with its waterways and natures other attractions.

Are there options for the three Senate recommended dot points below that will cater for the Lower Lakes and Channel.

- *modifying some of the barrages (such as Tauwitcherie and Mundoo);*

- *allowing the ingress of salt water into the Lower Lakes during periods of low flow;*

- *and investigating the construction of an additional lock at a location above Lake Alexandrina, such as near Wellington, SA either in concert with the above options or as a single change.*

There are options including a very progressive proposal as discussed 'in brief' below!

***A Better Way–for the Murray Darling Basin*, is a 13-page paper first released in early 2012 and further updated by the author, Investigative Journalist in Marine & Aquatic Ecology, Ken Jury of Goolwa in South Australia. Contact details on final page.

A Better Way –for the MDB was written following extensive investigations across the whole Murray Darling Basin, with a view to providing a suitable basin-wide solution to Australia's largest food growing crisis while enduring reduced freshwater availability throughout!

"A Better Way" for the Murray Darling Basin!

The full paper version is supplementary to the documentary *Muddied Waters - A Clear Solution* that screened in December 2012. Copies of this paper available by emailing to the author! Details page 6.

The full version describes how:

• It won't cost the earth – certainly not A$13 billion dollars.
• It won't damage floodplain farms and force farmers from their land.
• No need for water entitlement diversion reductions to service a government wish.
• Will use only a portion of the freshwater volumes currently used for the Lower Lakes etc. with provision to hand back the balance for productive upstream use.
• No need for costly over-bank flooding and subsequent property damage.
• No disruption for growers - improved growth in Australian foodstuff production and export.
• Growers and communities throughout the basin and the nation will benefit.
• Massive sulphuric acid mobilisation below Lock One will be checked.
• Murray River environments, aquatic life and biota will benefit.
• A working estuary will reward immeasurably with huge benefits and because:
• The MDB and the Lower Lakes are within a highly variable system.

The Lakes will remain a reversible system – fresh generally during natural flooding and estuarine at other times. Climate Change with sea level rise is already upon us. It will make all of this inevitable by (circa) 2050. This will affect the 7.6km barrages and all of the island embankments between.

Briefly, with: **A Solution for the Murray Darling Basin!**
All it will take is one more river Lock; we'll call it Lock Zero given the current first lock is located some 275km upstream of the Murray Mouth at Blanchetown in South Australia. With minor barrage adjustments and the removal (or part removal) of an unwanted island adjacent to the mouth, that grew from being a sandbar, the basin and our food security can then be saved.

Lock Zero should be built to regulate minimal freshwater flow to (40%-1800GL/per yr) into Lake Alexandrina to mix with ocean water, forming and maintaining an estuarine environment, and for the first time, provide for the control of the pool height between Lock One at Blanchetown and Lock Zero, while providing the means to greatly assist in clearing the Murray Mouth. This will create a saving of 2700GL of freshwater to grow our food!

This will rid the lower river section below Blanchetown of acid mobilization, so bad at times that even the authorities openly admit defeat with treatment of mobilised acid-laden water, notwithstanding a possible threat to the intake pipes that feed potable water back to Adelaide hills reservoir storages.

By retaining the barrages, freshly mixed estuarine water would be held within the lakes system for extended periods, and released out of the lakes/channels, from selected barrages occasionally to refurbish and provide strong scouring flows, to regulate the removal of silt and sand from the areas between the barrages and the Murray Mouth outlet to the sea.

Using lakes stored estuarine water, the system could be flushed at will through the barrages while replenishment for the lakes would be activated with free ocean water on the next incoming tide, followed by mixing with a small portion of freshwater stored behind Lock Zero to be naturally mixed by wind seiche!

In flushing the lakes; by allowing lake levels to recede by up to a maximum of 20cm only by opening selective barrage gates, estuarine water from the 840 sq km surface of the lakes will provide flushing volumes of scouring water for the river mouth at a rate in the order of 150GL used in one single out going tidal session to successfully scour and clear the mouth.

To enable selective flushing, an upgrading of the logs in the Goolwa Barrage is recommended given the lifting of the current single barrage concrete logs stacked on top of each other is both cumbersome and time consuming as they're handled individually - one by one as commonly seen at this barrage today.

The alternative in each of the Goolwa barrage compartment bays is for single, thick walled poly tanks to fit the overall slot in each bay, to operate by using nearby water through a single pump to each tank as the hydraulic in one 'single lift and fall motion' to enable necessary increased flow pressure with outflows to assist in clearing the mouth and keeping it clear. Equally, to provide opportunity to direct outflows of estuarine water towards the mouth with a view to a portion of this water flowing though to the
southern section of the northern lagoon of the Coorong.

The removal of a sandy, highly vegetated knoll that badly restricts outgoing water passage through the Mundoo Channel, located directly opposite the Murray Mouth. Bird Island as its known faces the river mouth, is located downstream of the Mundoo Barrage in the Mundoo delta on the edge of the Coorong. Its removal is necessary as it blocks about 70% of the flow from this barrage to the mouth. This obstruction and a minor connected peninsula gradually formed and vegetated as a result of building the

Mundoo barrage. It also impedes movement both ways of Coorong water, and water released from the Mundoo Barrage and 3 other barrages within the area that would otherwise clear the mouth of sand and silt. These changes are necessary for allowing the Lower Lakes system to require much less freshwater.

Simplistic perhaps, but logically there's a view to reduce the fresh water maintenance volume for the Lower Lakes to 40%, (about 1800GL/yr) as a freshwater allowance required to mix with barrage entrapped, highly oxygenated Southern Ocean water for the return of a healthy estuarine system within the Lower Lakes.

A Reversal of the system has many possibilities:

There're often seasonal periods when the elected 40% or 1800GL/yr of freshwater required for mixing in the lakes may be further reduced due to seasonal Lofty Ranges rain run-off reaching the lakes. A handful of streams actually reach the Lower Lakes including Currency Creek and the Finniss and Angus River's that yield significant winter freshwater flows that often reach Lake Alexandrina. This Lofty Ranges run-off water will again help compensate growers or it could be held as future fresh water meant for the lakes (to mix with ocean water), being held upstream of Lock Zero for this purpose. Moreover in an adaptive way of thinking, to suit the situation at the time when ensuring the continuity of the estuary or, if additional fresh flows persist through flood or minor flood, then ocean water and flood water would be adjusted by way of the now rejuvenated barrages and through Lock Zero to suit the situation. An upgraded Lower Lakes system as proposed would still be a reversible system. During low river flows it should be estuarine while river flood times may enable the river to completely fill the confines of the Lower Lakes as was generally the case. In all circumstances the freshwater or estuarine water biota throughout will adjust both ways as it most certainly always does in an estuarine environment!

Estuarine water:
Importantly, estuarine water can be made up of varying degrees of fresh and ocean water as is naturally the case in most estuarine deltas worldwide. Contrary to claims (and alleged state Govt. tests and claims in the Lower Lakes), estuarine water occurs at varying levels in deltas of most estuaries worldwide. These are often healthy eco-systems that provide immeasurable benefits to communities and governments alike.

Returning the Lower Lakes to estuarine would once again create a highly productive and useful environment. **However, the barrages are necessary in this case!**

Estuaries 'the world over' are known for their productiveness!
Such the case with viable fisheries known to exist in the Lower Lakes in pre-barrage times! It's a known fact that Mulloway (one of many examples of quality commercial fish known to the region) would gradually return to the Lower Lakes again to become part of a major fishery and fisheries nursery and breeding ground, for the return of large, productive fishery. In turn, tourism throughout would surge ahead and so would development!

Ken Jury of in SA – Senior Investigative Journalist (Marine & Aquatic Ecology), May 2016. Contact: