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Submission in respect of the Guide to the proposed (Murray-Darling) Basin Plan

By Ian Mott

With specific direction to:

Chairman, Michael Taylor, and, Dianne Davidson, Diana Day, Robert Freeman, David Green and Barry Hart

Comprising evidence and issues that are capable of establishing that the process outlined in the document described as the *Guide to the proposed Basin Plan* is;

A. **A grossly improper exercise of power** within the meaning of Sections 5 & 6 of the *Administrative Decisions (Judicial Review) Act, 1977* http://www.austlii.edu.au/au/legis/cth/consol_act/adra1977396/s5.html and,

B. A planning process that is **in serious breach of** both the letter and the spirit of the **Intergovernmental Agreement on the Environment, 1992**.
http://www.austlii.edu.au/cgi-bin/sinodisp/au/legis/cth/consol_act/nepca1994432/sch1.html?stem=0&synonyms=0&query="intergovernmental%20agreement%20on%20the%20environment" and,

C. Conduct that is in **grossly negligent abrogation of Professional Duty of Care** to take all reasonable and practical steps to prevent entirely foreseeable and avoidable harm to all persons with an equitable interest in the proper management of all waters of the Murray-Darling Basin.

Overview:

The Murray-Darling Basin Authority (MDBA) has misinterpreted the objects of the *Water Act, 2007* in a way that assumes that only the fresh water resources of the basin are available for achieving the purposes of that Act. The interaction of fresh and tidal waters of the Coorong and Murray mouth is the critical element in ecosystem health and end of system dynamics. Yet, the character, frequency and volumes of these tidal flows have not been included in the inventory of Basin water resources and no meaningful attempt has been made to consider the enhanced management and augmentation of this resource for achieving the objects of the Water Act, 2007.

This appears to have its roots in one of the most appalling intellectual cop-outs ever incorporated into a policy process, the second conclusion of Walker [1](2002) who said;

> **"The build-up inside the mouth is believed due to a combination of inadequate river flows and near shore coastal processes related to wave and tide climate. Engineers and managers have no control over the latter".**

The second sentence is a gross, and inexcusable, misstatement of fact, by omission of the incredible range of works carried out all over the world, and over more than 3000 years of history, to mitigate and manage the impacts of wave, tide and storm events.

Executive Summary:

A. The major determinants of the condition of the Murray River mouth are the asymmetric tidal patterns and storm induced wave heights that produce a build up of beach sediments in a standard "flood tide delta" inside the mouth.

B. Half of all daily tide patterns (week about) involve approximately 8 hours of rapid inflow that deposits sand, followed by 16 hours of slow outflow that doesn't remove it.

C. The shear stress of a flow (its capacity to move sediment) increases at approximately the square of the flow speed. So an inflow that is twice as fast as the outflow will transport four times more sand than the outflow will remove.

D. Half of all river flows take place at times of each lunar cycle when the tidal variation is minimal and the capacity to remove sediment is severely retarded. So half of the 3 million ML of buy-back water will not do the job intended for it. Nor will half the 5 million ML of existing flows.

E. An increase in total river flows that removes sand will simply increase the capacity of tides and storms to put it back again.

F. The function required of increased outflows is purely hydrological. It can be done equally well by additional sea water that has not already come through the mouth. Sea water is in essentially unlimited supply and comes at zero FOB cost.

G. Storm events compound the deposition problem by increased turbulence (transportability) and increasing inflow volume and velocity. Of the annual average 77 storm events, only 38 coincide with large tidal variances and only 14 of those have their storm surges coinciding with rapid tidal intakes. The latter can deposit up to 46,000m3 of sand in a single event and cause most of the deposition problem.

H. These events can only be countered by timely and fully proportionate outflows that negate the deposition multipliers. A continuous modest flow after or between these events cannot redress the original deposition problem.

I. Large dimension, unidirectional pipes under the dunes, with intakes below the wave zone and above sea bed sand, can passively deliver the volumes of clean sea water needed to ;

a. First, retard deposition through reduce volumes and velocities of river mouth inflows as a larger portion of the tidal prism is supplied via the pipes, and
b. Then produce the increased volume and velocity of outflows by blocking the reverse flows back out the pipes so the outflow is diverted to the Murray mouth where its greater volume and velocity will increase sand removal to equilibrium levels.

J. Two pipes at the far end of the Coorong, and one north of The Narrows, could produce a complete cyclical discharge of the hypersaline volume of both lagoons out through the Murray mouth, and its replacement with cool, oxygenated sea water.

K. Less than 13 pipes either side of the Murray mouth could negate the deposition of all major storm events and do a better job, much cheaper, than all current river flows and additional buy-back water combined. Dredging will reduce the number of pipes required.

1.0 General Principles:

1.01 No legislation, policy or plan should be framed or interpreted in a way that gives effect to an improper exercise of power.

1.02 Improper exercise of power includes;

(a) taking an irrelevant consideration into account in the exercise of a power;

(b) failing to take a relevant consideration into account in the exercise of a power;

(c) an exercise of a power for a purpose other than a purpose for which the power is conferred;

(d) an exercise of a discretionary power in bad faith;

(e) an exercise of a personal discretionary power at the direction or behest of another person;

(f) an exercise of a discretionary power in accordance with a rule or policy without regard to the merits of the particular case;

(g) an exercise of a power that is so unreasonable that no reasonable person could have so exercised the power;

(h) an exercise of a power in such a way that the result of the exercise of the power is uncertain; and

(j) any other exercise of a power in a way that constitutes abuse of the power.

1.03 The proper exercise of power in respect of environmental planning is in major part informed by the Intergovernmental Agreement on the Environment, 1992 which states that;

> 3.3 The parties consider that strong, growing and diversified economies (committed to the principles of ecologically sustainable development) can enhance the capacity for environmental protection. In order to achieve sustainable economic development, there is a need for a country's international competitiveness to be maintained and enhanced in an environmentally sound manner. And,
>
> 3.4 Accordingly, the parties agree that environmental considerations will be integrated into Government decision-making processes at all levels by, among other things:
>
> (i) ensuring that environmental issues associated with a proposed project, program or policy will be taken into consideration in the decision making process;
> (ii) ensuring that there is **a proper examination of matters** which significantly affect the environment; and
> (iii) ensuring that **measures adopted should be cost-effective and not be disproportionate to the significance of the environmental problems** being addressed.

1.04 The objects of the Water Act, 2007 are entirely consistent with the principles outlined above. The MDBA is required to;

- Give effect to relevant international agreements
- Protect, restore and provide for the ecological values and ecosystems services of the Basin
- Promote the use and management of Basin water resources in a way that optimises economic, social and environmental outcomes
- Ensure the return to environmentally sustainable levels of extraction for water resources that are over allocated or overused
- Maximise net economic returns to the Australian community from the use and management of Basin water resources while protecting, restoring and providing for the ecological values and ecosystem services of the Basin.

1.05 However, the term, "Basin water resources" includes fresh water sourced from outside the Basin catchment that has been, or could be, introduced to the Basin by human intervention (e.g., by pipeline from the Snowy River catchment). And it must also include sea water that has been, or could be, introduced to the Basin by human intervention.

1.06 The provision for adequate introduction of sea water into the Coorong and other parts inside the Murray mouth is clearly a core ecological value and ecosystem service in its own right. It clearly falls within the meaning of the first Mandatory Decision required by the Water Act, which is to;

- Determine the amount of water needed for the environment, known as the environmental water requirement, to protect, restore and provide for the ecological values and ecosystem services of the Basin.

This obligation clearly includes determining the amount of sea water needed to provide for the estuarine ecological values and ecosystem services. But the MDBA only includes it as an outcome, not as a tool for achieving outcomes.

1.07 Once the sea water environmental water requirement has been determined then there is a clear obligation under the objects of the Water Act 2007, and under Clause 3.4 (iii) of the Intergovernmental Agreement on the Environment to examine the most cost effective means of introducing that water and ensuring that the water is delivered in the correct proportions to the need for it.

1.08 The consideration of all practical options for the substitution of sea water, to perform tasks that have been historically performed by fresh water, clearly falls within the obligations of proper exercise of power, of ensuring cost effective and proportionate measures under the IGAE, and the discharge of professional duty of care. But neither the process outlined, nor the diagram, on page xiii of the guide includes any provision for examining alternative options.

2.00 Essential Facts:

2.01 A purely hydrological function like the transportation of sand and sediments can be, and currently is, performed with equal effectiveness by equal volumes and velocities of sea water or fresh water.

2.02 **Fresh water** is a comparatively scarce resource and is subject to substantial variation in supply. Any ecosystem service that is dependent on the supply of fresh water will be subject to substantial periods of non-delivery of that service.

2.03 Competition for the use of fresh water resources will continue to increase over time with resultant increases in the market price for that water.

2.04 The current spot price of irrigation water is in the order of $200 per megalitre while the capital cost of an annual allocation, that may or may not actually be available, is in the order of $2,000/ML.

2.05 If the future supply of fresh water is reduced, by either reduced rainfall or reduced run-off, or is limited by water buy-backs then demand pressures will increase the cost of water. Supply pressures, as the cost of storage and delivery infrastructure is defrayed over a smaller supply volume will also contribute to rising prices of fresh water, and through it to rising costs of ecosystem services provide by fresh water.

2.06 **Sea water** is one of the most abundant natural resources on the planet. Its supply is only limited by distance from the ocean, the height above sea level of the use it is put to, the presence of impediments to its transport and the cost of capture and delivery. An ecosystem service that is dependent on the supply of sea water need not be subject to any significant periods of non-delivery.

2.07 Competition for the use of sea water resources is minimal. This competition may grow over time but this will have minimal effect on the abundance of the resource or its price. There are no foreseeable market pressures for cost increases on ecosystem services delivered by sea water.

2.08 The current spot price of sea water is zero dollars per megalitre and the capital cost of an annual allocation, that will always be available, is also zero dollars/ML.

2.09 When sea water can be substituted for fresh water the limit to the annual cost of any infrastructure required in its capture, transportation and delivery to the place of use is defined by the spot price/ML of the fresh water it is replacing. The capital cost of infrastructure for the delivery of sea water is defined by the market price/Ml of a fresh water allocation, plus an additional premium for the substantially improved reliability of sea water supplies.

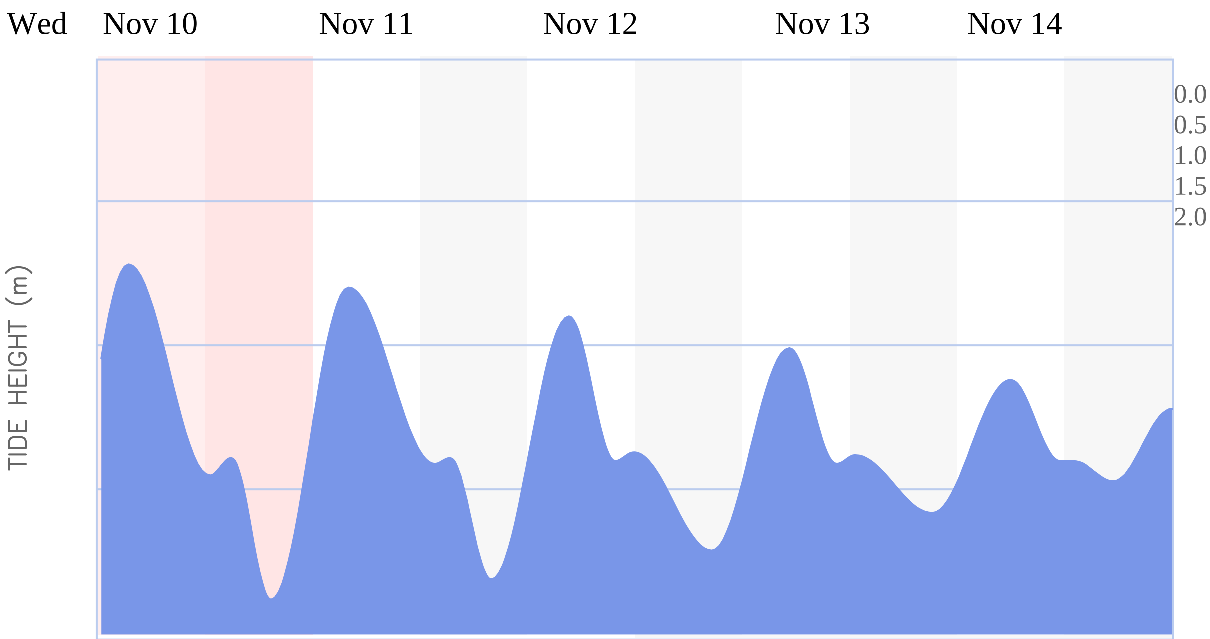
2.10 The difference between the market price of fresh water and the delivered cost of sea water is the marginal profit from the substitution process. The gross profit from the substitution is the marginal profit x the volume of all fresh water supplied.

2.11 The historical range of variation in the proportions of fresh and sea water that have delivered the essential ecosystem service of maintaining adequate tidal flows inside the Murray mouth is from zero fresh water and 100% sea water, in times of extended drought, to 100% fresh water and zero sea water in times of major flood.

2.12 According to Harvey[2] (1996) the tidal prism inside the Murray mouth has declined by 87-96% since the introduction of the Barrages, from an original volume estimated by Walker[3] (1990) of 20,000 ML.

2.13 No comprehension of the true interplay of tidal flows on the state of the Murray mouth is possible without reference to the **Goolwa Beach tidal curve** below.

This graph is the **Goolwa Beach** tide chart represented as a curve. It shows the tidal range, as well as tide height for different times of the day. The tide height data is provided by the Australian Bureau of Meteorology and the Australian National Tide Tables for standard ports. See http://tides.willyweather.com.au/sa/fleurieu-peninsula/goolwa-beach.html



2.14 This graph shows the transition between the two predominant tidal patterns that prevail at the Murray mouth. These patterns alternate for approximately a week each with two of each type in each lunar orbital cycle.

2.15 At left, (Nov. 10 & 11) we see the asymmetric pattern with maximum inflows over 8 to 9 hours followed by maximum outflows over 16 to 17 hours. This produces a substantially higher flow velocity on the inflow compared to the outflow and clearly illustrates why the sand build up inside the Murray mouth is driven by tidal dynamics.

2.16 At right, (Nov. 14) we see the alternate pattern of minimal tidal flux with minimal capacity to move sand in either direction. At these times the water in the mouth is deeper and slower, with neither volume nor velocity on a scale that is capable of moving sand. **As these minimal tide variations take place every second week, it follows that 50% of all river flows occur when they cannot perform the ecosystem service they are intended to perform.**

2.17 There is also a 20cm annual variation in mean sea level with lowest levels in Summer/Autumn, which coincide with periods of lowest river flows, and highest levels in Winter/Spring, which coincide with highest river flows.

2.18 The maximum potential for discharge water to carry sand out through the Murray mouth is when mean sea level is lowest. Potential for sand removal is lowest when mean sea level is highest.

2.19 The peak river flow volumes take place at a time of year when the capacity to remove sand from the mouth is declining.

2.20 The maximum potential for deposition of sand within the Murray mouth is when mean sea level is highest. According to Webster[4] (2005),
"The modelling and measurements presented by WBM Oceanics[5] (2003) show that this transport is likely to be particularly intensive under conditions of high waves and spring tides."

2.21 Webster then advised that;
"In a two week period between 14-28 May 2002, which included a storm having offshore significant wave heights of ~4m and spring tides, approximately 46,000m3 of sand was deposited in the shoals and channels inside the mouth."

2.22 According to Chappell[6] (1991) there were 3,849 significant storms between 1940 and 1990, mostly frontal systems, an average of 77 each year and evenly spread.

2.23 Only very large river flow volumes can balance water levels inside and outside the Murray mouth during storm surges in a way that would counteract the hydrological forces in major sand deposition events. Walker[7] (2002) graphed the damping of the tidal signal at Goolwa by a large river flow from 1-7 October 1990. This produced mean water levels 0.44m above that of Victor Harbour on a flow of 2,658GL/month. This is a full 1,100 GL/month more than his claimed natural peak flows of 1550 GL/month from August to November each year.

2.24 Once large sand volumes obstruct the mouth then the capacity of combined river and tidal flows to remove that sand is seriously impaired.

2.25 Storms during periods of lower river discharge, historically from February to June, deposit the most sand volumes because the imbalance between ocean and estuary water levels is greatest. The reduction in river flow volumes has expanded this window from November to July and even medium storms now cause deposition.

2.26 The addition of an evenly distributed 3,000 GL/year (250 GL/month) from water purchases will not substantially alter this window, even if it is combined with extra releases from the Barrages.

2.27 The build up of sand within the mouth has produced events described as "mouth closure" as shown below. (From Walker, 2002)

Figure 2.2 River Murray Mouth in April 1981 showing full blockage at the Mouth and restriction of water exchange between the Goolwa (left) and Tauwitchere (right) Channels.

2.28 The width of the Goolwa Channel at left is approximately 400 metres with the moist portion of the mouth being about 200m wide. A 46,000m3 volume of sand at a nominal depth of 1m, as described by Webster (2.11 above) as being deposited in a single storm event, would occupy the rough square feature bounded by shoals in the mid-left of centre of the picture.

2.29 This image was clearly taken at the lowest tide of the month at a time of year when mean sea level is also low. It only appeared this way for less than four hours of that 24 hour period. Just 8 hours later the mouth was very much open again, with an additional 1.2 metres of water depth and less than a week later there was an almost constant 0.6m depth.

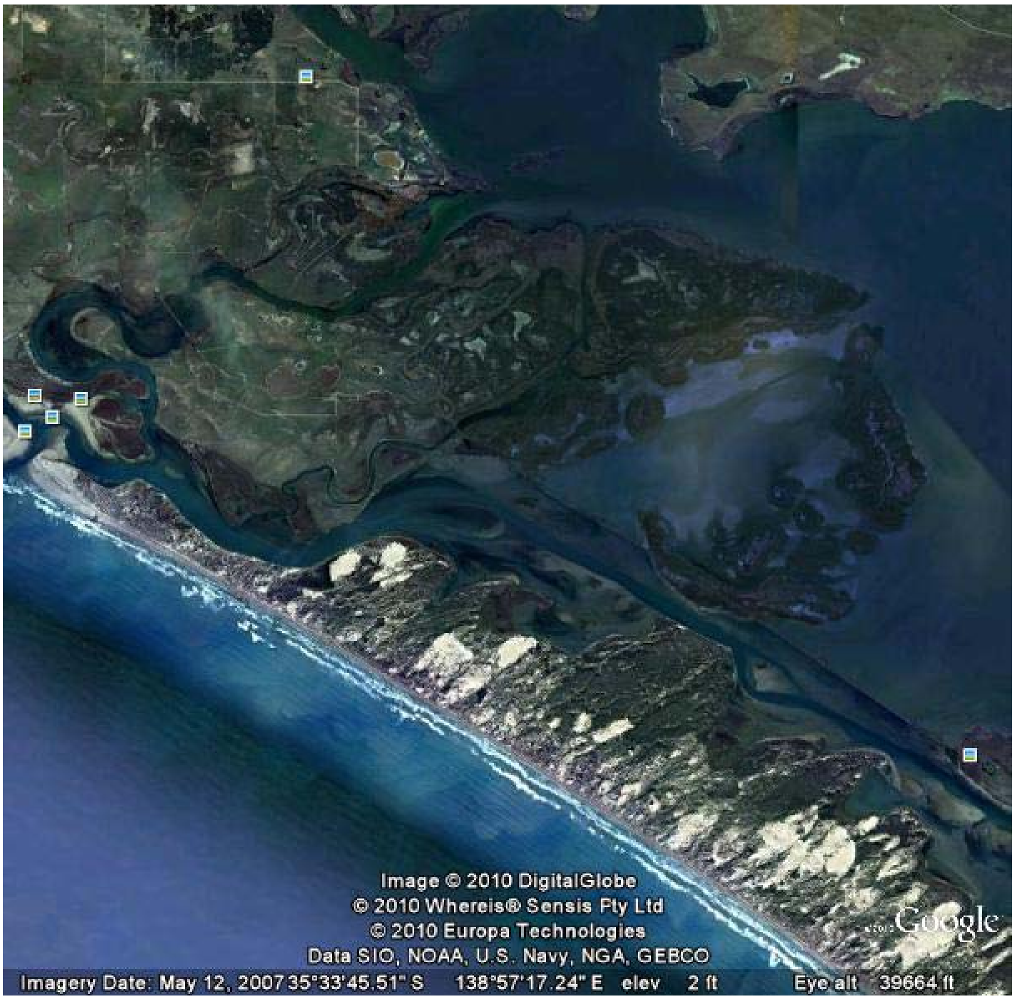
2.30 Human intervention can alter the natural constraints of the site. If this were a river mouth anywhere in NSW or SEQ there would be a breakwater to manage sediment deposition by both river and beach.

2.31 A more recent image of the Murray mouth in May 2007 shows the contribution made by a rather modest dredging operation in a period of severe drought.

2.32 Despite this open mouth the ecological values and ecosystem services of the Coorong are not being maintained. Periodic very large flows may have been able to protect these values but it is simply the distance from the mouth that has most influence on the intrusion of the fresher tidal waters on which this ecosystem depends.

2.33 According to Webster[8] (2005) only the long term trends make it into that system. **"Low frequency water level variations in Encounter Bay, such as those associated with the passage of weather systems, penetrate more effectively through the mouth and along the Coorong than more rapid level fluctuations such as those due to the tides. Similarly, the width and depth of the mouth affect its ability to transfer water level fluctuations into the Coorong."**

2.34 The distance from the Murray mouth at left of the photo below to the start of the North Lagoon at the lower far right is 15km and the channel width averages about 300m for a surface area of approximately 500ha. There is another 320ha over 7.2km in the Goolwa channel further left.



2.35 A Manning Equation for this channel is difficult due to roughness variations. But if a uniform, 3.6 metre pipe covered this distance, and the upper half of the tidal range (0.5m) was used to define the slope for a Hazen-Williams[9] formula for a gravity fed pipe flow then the flow velocity would only be 0.425m/sec and discharge only 4.33m3/s or 15.6 ML/hour. It would take 9.8 hours for water to flow the full length of the pipe, by which time the tide would already be on its way back out again. http://www.calctool.org/CALC/eng/civil/hazen-williams_g

2.36 In reality the slope of a tidal inflow is much less than half the tidal range. The natural tidal flow has difficulty fully supplying the potential tidal prism. Flow distance is critical. The further from the mouth the greater the variance between the potential and the actual prism as the tidal signal gets weaker and weaker.

2.37 The same size pipe extending from 200m out to sea (beneath the low tide wave influence) for 1500m under the dunes at lower right corner would flow three times faster (1.47m/sec) and discharge at 15.0m3/sec. The water would arrive only 17 minutes after entering the pipe and discharge 54 ML/hour.

2.38 Similar pipes under the narrower dunes closer to the mouth in either direction and with a length of only 600m would have a velocity of 2.4m/sec and discharge 24.6m3/sec. The water would arrive only 4 minutes after entering the pipe and discharge 88 ML/hour.

2.39 During storm surges the velocity and volumes of pipe flows would be much greater. If a storm surge added 0.5m to the slope then velocity in the pipes at 2.38 above would increase to 3.5m/sec and the discharge rate would be 35.8m3/sec. The water would arrive 2.85 minutes after entering the pipe and discharge 129 ML/hour.

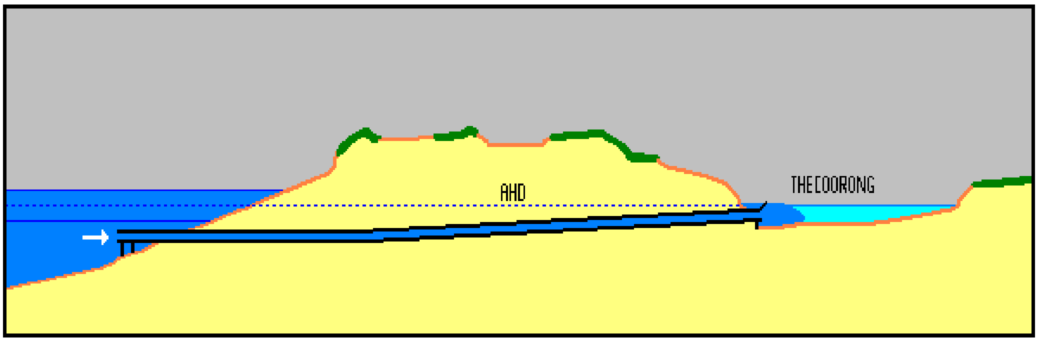
2.40 The fundamental contradiction in the current management of the Murray mouth is the fact that the more open (wider and deeper) the mouth is made by a large river flow, the greater the ensuing tidal movements become and the more able the tide and storm forces get to dump sand back to close the mouth up again. Tinkering with the volumes will not alter this dynamic.

2.41 **Open Channels** through other parts of the dune system have been proposed as a means to improve ecological values in the Coorong but this is problematic. Channels must function in the littoral zone and would be subject to all the same natural processes that currently block the Murray mouth. In the absence of any countervailing river outflows, they would silt up even faster than a river mouth.

2.42 Any form of additional openings to the sea would only deliver a useful ecological service if they flowed in one direction only, in from the sea and along the existing channels and out through the mouth. This one-way flow would increase the total volume and velocity of tidal outflows and perform exactly the same equilibrium ecological service that fresh water discharges have done in the past. This is the only way to increase total tidal inflows without dragging extra sand into the mouth itself and closing it up again.

2.43 However, the absence of reverse flows in a channel system would only serve to ensure that the artificial gap in the active dune system closed even faster.

2.44 **Pipes under the dunes,** on the other hand, have major advantages over open channels for delivery of additional sea water to barrier estuarine systems;



- They can deliver precise and standardised volumes of sea water over a much shorter distance in a fraction of the time taken by passive tidal systems,
- They can be replicated to deliver sea water to any desirable location along a barrier system,
- They can provide variable delivery of sea water to optimise flows in the system,
- They can be completely covered once in place to restore visual values,
- Their oceanic intake can be placed lower than the wave zone to reduce risk of storm damage,
- The oceanic intake can project a sufficient distance out of the sand body to ensure that it free of sand in suspension and hence, sand will not be transported through the pipes in any sea condition or intake velocity.
- The pipe will not form a groyne-like barrier to lateral movement of sand along the beach and no (internal) flood tide deltas will form at the other end that would otherwise continually restrict the pipes function.

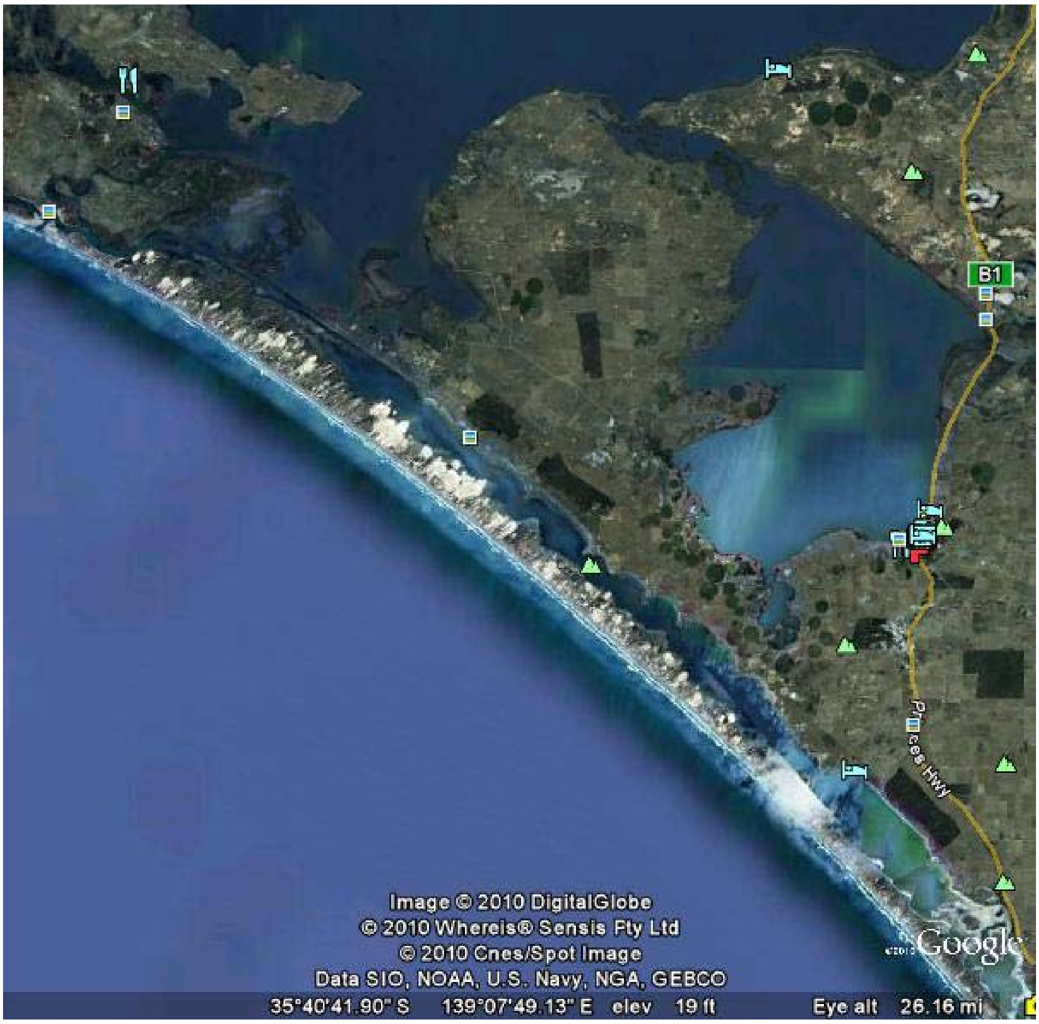
2.45 Such a system would operate passively, responding immediately to various levels of tidal flux without management input and in direct proportion to the height of any storm surge. But the presence of a simple valve system would also enable complete or partial shutdown if or when required.

2.46 **The system could function at a number of levels;**

- **As a simple source of fresher water to overcome seasonal hyper salinity and replace evaporation losses in the closed end system.**
- **As a general augmentation of existing volumes into the far reaches of the Coorong to produce an increase over normal water levels and create a net outflow which will discharge excessive and unsustainable saline build-up out through the river mouth.**
- **As a tool for accurate, timely and proportionate adjusting of flows in and out of the mouth so normal rates of sand deposition can be reduced and countered by increased rates of sand discharge.**
- **As a tool for timely and proportionate responses to reduce the extent of major storm surge sand deposition events as and when they occur.**

2.47 The Coorong is now a closed end system. Variations in water levels at the front of it have minimal impact at the far end. In the absence of pre-settlement flows along its length from the South East Drainage System, no amount of fresh water flows adjacent to the northern end can deliver adequate ecosystem services.

2.48 **The North Lagoon** is 48km long. Its average width at AHD is 1.5km, depth is 1.2m, surface area is 7,200ha and volume is 86,400 ML (CFMI[10], 1992). Mean annual pan evaporation is 16 ML/ha so the actual (80%) is more like 12.8 ML/ha. Mean annual rainfall is 5 ML/ha giving a net evaporative loss of 7.8 ML/ha. It requires an average 56,160 ML each year (65% of volume) to replace net evaporation losses.



2.49 Even if all this volume came from fresh water delivered over the Tauwitcherie Barrage in the upper left corner it would only serve to temporarily dilute saline levels rather than reduce existing salt loads. The current, totally inadequate, policy of reliance on tidal "sloshing" of fresh water to maintain water quality requires a much greater volume of fresh water that is delivered in a poorly targeted manner by an extremely inefficient method.

2.50 Year round direct injection of tidal water to the southern end of the North Lagoon, in volumes capable of keeping pace with mid summer evaporation rates, by pipes will fully restore and maintain all ecological values and ecosystem services through a complete replacement of water volume.

2.51 Summer evaporation is 0.056 ML/ha/day with a gross loss of 403 ML/day. In the absence of storm surges only half the days of each cycle will have tidal variation capable of producing useful inflows so the daily pipe flow must be in the order of 806 ML/Day, over an 8-9 hour high tide interval.

2.52 The passive flow rate will vary as the tide height outside the dunes rises and falls in relation to the mean sea level inside the dunes. An average cycle of the type shows at left of the graph at 2.13 above would have two hours (first and last) of a 10cm drop, 2 hours each of a 20cm, 30cm and 40cm drop, and a peak hour of 50cm drop that defines the rate of inflow.

2.53 Over a single1000m pipe of 3.6m diameter this would produce passive flow of;
2 hours @ 7.83m3/sec for 56 ML
2 hours @ 11.39m3/sec for 82 ML
2 hours @ 14.18m3/sec for 102 ML
2 hours @ 16.56m3/sec for 119 ML
1 hours @ 18.68m3/sec for 67 ML
For a total discharge of 426 Megalitres a day.

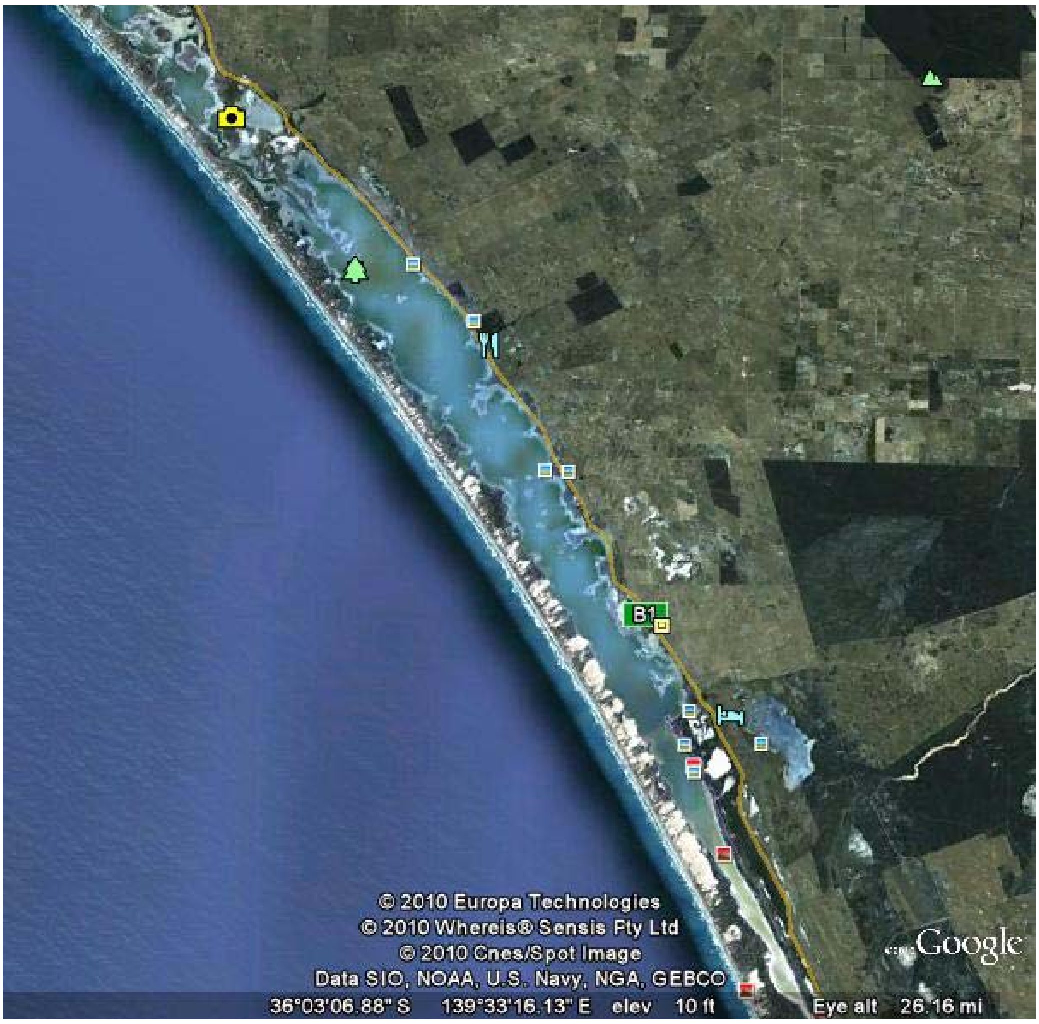
2.54 A 20cm storm surge on such a day is likely to add another 295 ML to the peak flow and 168 ML to the lower flows, taking the daily discharge to 890 ML.

2.55 An annual 180 days of such normal flows would inject 76,600 ML to the North Lagoon. Add the mean annual rainfall of 36,000 ML and the total water increment is 112,600 ML. Deduct the evaporation loss of 56,200 ML and we are left with a minimum net injection of 56,400 ML each year, or a 65% turnover of the original volume.

2.56 Based on normal flows only, this 76,600 ML would deliver in full, and well, the ecosystem services that a much larger volume of fresh water spilled over the Barrage does only partially, and poorly.

2.57 This volume of repurchased irrigation water, even if it could be delivered, free, to the southern end of the North Lagoon to produce a proper flushing outflow to the mouth, at $200/ML, would have an annual value of $15.3 million and the capital purchase price of the allocation required for continual use would be in the order of $153 million. The value of storm surge inflows would increase these comparative values.

2.58 **The South Lagoon** is separated by a string of shoals called the narrows (below) where the inward "sloshing" of tides is even more restricted. It is 40km long and has an average width of 2.5km, a depth of 1.4m, a surface area of 10,000ha and a volume of 140,000 ML (CFMI[11],1992). Annual net loss to evaporation in the South Lagoon is 78,000 ML (55.7% of volume).



2.59 This evaporative loss is not matched by inflows during mid-summer when water levels can fall as low as 0.5m below AHD.

2.60 A single 3.6m pipe of 1000m length as described above would not replace the net evaporative loss under normal discharge rates. But the additional flow produced by storm surges is likely to produce a net discharge into the North Lagoon.

2.61 If half the annual 77 storm events reported by Chappell[12] (at 2.22) took place during the peak tidal variation periods, and each event only lasted one day, and the mean tidal surge was only 0.2m, and there were no additional benefits from surges during neap tides, then there would be 38 days on which inflows would increase from 426 ML/day to 890 ML/day. This would add another 18,000 ML to the normal inflow to produce a total of 94,600 ML and an annual discharge, after net evaporation loss, into the North Lagoon of 16,600 ML.

2.62 This would represent an annual exchange of just less than 12% of the South Lagoon's 140,000 ML normal volume. And it would take eight years to completely replace this volume and bring salinity levels back to that of sea water.

2.63 A second pipe would achieve that outcome in less than a year.

2.64 The delivery of the same ecosystem service with 94,600 ML of fresh water, if it were available from the SE Drainage System, would cost $18.9 million a year and require a capital outlay for allocation buy-backs of $189 million.

2.65 A shorter length of pipe, or a larger diameter of pipe, or the construction of a wider open channel, part of the way through the dune system from the discharge (Coorong) side, to link with a shorter pipe, would increase the volume and velocity of tidal inflows further.

2.66 It is improbable to the point of disbelief that the construction and emplacement of a single kilometre of pipe would cost more than the capital cost of the fresh water irrigation allocations such a pipe would replace.

2.67 This point is doubly important in light of the fact that none of the 3,000,000 ML of additional river flows requested by the MDBA will actually be delivered to the South Lagoon, and very little to the North Lagoon. Yet, it is the very hyper-salinity and associated habitat degradation in the Coorong that has been provided as the primary justification for that additional flow.

2.68 Indeed, even in the unlikely event that the through life cost of a pipe was as high as the value of the fresh water volume it replaced, the 3,000,000 ML proposed by the Guide would purchase more than 31 pipes.

2.69 But given that half of that proposed 3,000,000 ML buy-back will flow out the mouth at times when tidal flows provide almost zero hydrological assistance, and it will be unable to respond in kind to the critical storm surge deposition events, and the fact that there are no value chain adverse economic impacts, including adverse tax base impacts, from substituting sea water for fresh water, then pipes will still be a superior option at triple that cost.

2.70 Lake Alexandrina and Lake Albert are the portions of the original tidal estuary that have been converted to fresh water lakes by the Barrages. They have a surface area of approximately 65,000ha, an average depth of 3m, a volume of 1.95 million ML, and are maintained at about 0.5m above AHD when fresh water is available. Gross evaporation is in the order of 832,000 ML/year which is off-set by mean annual rainfall of 325,000 ML, for a net loss of 507,000 ML/year.

2.71 Many people, including myself in the past, have criticised this evaporative loss as a waste of fresh water which had formerly been supplied from tidal flows. But this is based on a misconception that past sea water in tidal inflows was at the surface and extended to cover most of the lake surface. In fact the colder, denser sea water would have intruded under the warmer, fresh water and, even with no loss of tidal signal, would only have extended to 30% of the lake area.

2.72 Historical anecdotal reports that all of the Lake area was fresh water, all the time, were most likely based on hand sampling of surface water from boats that did not sample the sea water tidal intrusion below the surface. Webster[13] (2002) refers to observed current examples of salinity stratification in the North Lagoon.

2.73 Calls for the removal of the Barrages, including my own in the past, have been based on the mistaken belief that this larger tidal prism would produce larger flows through the Murray mouth that would then help maintain the mouth in an open state. But the tidal asymmetry shown at 2.13 above makes it clear that a larger prism would simply increase both the volume and velocity of inflows but maintain the imbalance with the volume and velocity of outflows. The result would be an increased potential and incidence of deposition inside the mouth.

2.74 The Barrages have actually reduced the scale of the deposition problem by reducing the size of the tidal prism. And this reduction has been most valuable during the major storm surge deposition events.

2.75 Open Barrages during periods of severe drought, and after evaporation losses have reduced lake levels to below AHD, can certainly contribute to maintaining ecosystem services and preventing impacts like acid sulphate leaching.

2.76 But it is surprising that, given official certainty of sea level rises of up to 1.0m by 2100, there has been no consideration of the implications of this on Lake management. If AHD is to rise by 40cm by 2040, then the level of the Coorong will then be only 10cm lower than inside the Barrages. And the capacity to discharge fresh water past the Barrages will be severely restricted. The clear implication will be that an extensive network of additional bunds will need to be constructed right around the perimeter of the Lakes to preserve a continually diminishing 50cm height differential inside the Barrages to preserve the capacity to discharge fresh water through the mouth.

2.77 Clearly, the use of fresh water as the primary tool for managing sediment deposition in the Murray mouth will require substantial additional capital outlays in the medium term simply to preserve the functionality of this tool.

2.78 It is also possible that an additional Barrage, extending the short distance from the eastern end of the Tauwitcherie Barrage, to the dune system may be needed. This could be left open for most of the time to maintain tidal movement into the North Lagoon. But in storm surge deposition events it could be closed to substantially reduce the tidal prism and thereby retard the potential for major sand build up.

2.79 This would limit the tidal area to just 820ha and would limit the rapid inflow volume in a peak tide to something in the order of 9,000 ML and 13,100 ML in a storm surge. And when combined with as few as 6 additional pipes under the dunes, could see more than half this total inflow diverted from the mouth while the total outflow could do its important sand removal work on its way out.

2.80 **Dredging** of sand has been[14] **"non-stop in the Murray mouth since the mouth almost closed in October 2002. In those eight years 5.9m m³ of sand has been pumped at an estimated cost of $40m, ensuring an exchange of water between the ocean and the Coorong."**
http://www.earthmover.com.au/news/2010/newswire/november/november-4th/other-top-stories/dredging-reduced-at-murray-mouth

2.81 The contract manager, Campbell[15] (2008) advises that 5.0m m3 had been shifted in the first five years at an average $6.6 million a year or $6.60/m3. By deduction, the last 0.9m m3 has cost $7 million over three years at $7.78/m3, reflecting the higher marginal cost from lower volume removals after the second dredge was stood down.

2.82 The lower removals after completion of the channels are in a context of zero fresh water discharges over the Barrages since 2006. It is now an incontestable fact that this single dredge maintained a functioning river mouth through the most testing circumstances in post-settlement history, and with annual removal of only 300,000 m3 and a cost of only $2.33 million a year.

2.83 The objectives for this project, set by the MDB Ministerial Council (9/2002), and noted by Campbell[16] (2008) were to:

- Lower the elevated water levels in the Coorong,
- Re-establish tidal variations, and
- Provide stable channels.

To achieve three ecological objectives:

- An open Murray Mouth – to ensure that there is connectivity between the Coorong and the sea,
- More frequent estuarine fish spawning and recruitment – preserving existing species and numbers for both economic and ecological reasons,
- Enhance migratory bird habitats/tidal response – ensuring that tidal fluctuations (providing cool oxygenated water) are preserved to protect the mudflats within the Coorong.

2.84 The Sand Pumping Technical Committee (SPTC) was formed to oversee the project. They **"considered a range of alternatives for keeping the mouth open. Twelve options were evaluated including dredging, sand by-pass, pumping, jetting, breakwaters, transferring water from the Upper South East, construction of a new mouth and piping the mouth. Conventional dredging was the cheapest option with the lowest level of risk".**[17] This evaluation does not appear to have been published.

2.85 The design called for a channel 80m wide and 3m deep from the mouth to the Tauwitcherie Channel and a 40m wide and 3m deep channel connecting the Goolwa side. And this was achieved by May 2006.

2.86 Campbell[18] concludes, **"The project has been, and continues to be, successful in achieving the primary objectives of keeping the Murray mouth open to maintain a tidal variation in the Coorong and to deliver cool oxygenated water into the Coorong, thus helping to maintain the ecological integrity of this internationally significant site".**

3.00 Assumptions

3.01 The plan embodied in this submission is based on the assumption that the MDBA, and the political interests directing it, are capable of acting in good faith.

3.02 It is assumed that the scientific community involved in this issue is capable of lifting themselves above the eco-Neanderthal belief system that would have it that any measure to protect or restore environmental values must come at the cost of pain and sacrifice by mankind in general, and farmers in particular.

3.03 It is assumed that everyone involved in the decision making process is capable of comprehending the fact that nature quite often operates within a highly inefficient set of parameters. And that by far the proudest aspect of human achievement has been their capacity to work with nature to deliver the same or improved ecological services with fewer, or better targeted, natural resources, to then enable themselves and their dependent species to make better use of the resulting ecological profits.

3.04 It is assumed that the well recognised and documented propensity of the resource management bureaucracies to snatch mediocrity, failure and substantial budgetary waste from the jaws of excellence, achievement, and profit, will not raise its ugly head in this instance.

4.00 What else do we need to know?

4.01 The average duration of storm surges, (i.e., the time taken for frontal systems to pass) and their range of variation, needs additional study, as does their mean height and their range of variation in height. Without this information the more accurate determination of the likely range of passive flow pipe yields cannot be made.

4.02 For the proper management of Murray mouth sand deposition we need to know the proportion, number, and range of scale variations, of storm surges that coincide with the periods of peak tidal variation. Storm surges that coincide with ebb and neap tides are likely to produce much less deposition because their rising inflows counteract the tidal outflows. Storm events where maximum surge takes place during maximum tidal inflow will present the highest volume and velocity inflows and produce the highest volumes of sand deposition.

4.03 We then need to know the extent to which these major deposition events must be negated and the extent to which their deposition volumes can be carried forward for remedial action by subsequent normal tidal outflows and benign phase storm surge outflows. This information will be essential for the ultimate design specification.

4.04 We need to know the proportion of total inflows that will need to come via conduits other than the Murray mouth to ensure equal deposition and removal on each tidal cycle. That is, when the combined outflows through the mouth can remove the deposition that took place on the previous inflow. At Alternative 5.50 below, we have assumed this to be 50% but the actual is likely to be much less because a unidirectional diversion system reduces deposition by diverting mouth inflows to the alternative conduit and increases sand removals by increasing the total volume of mouth outflows via improved efficiency of the tidal prism.

4.05 We need to know the optimum size, volume, cost relationships in both pipe construction and installation. This analysis has used 3.6m diameter pipes as a standard but we need to know, for example, if smaller ones provide substantially lower cost advantages that outweigh the resulting reduced flow volumes. It may also be possible that larger pipes produce flow gains that outweigh their increased cost and installation difficulties.

4.06 Optimum pipe size will also be influenced by installation issues on the seaward side with questions over a single large prefabricated sub-surface interface or an on-site construction with coffer dams etc.

4.07 The trade-offs between large capacity passive flow systems that only function for part of the time, and smaller capacity pump based systems that can function all of the time would also merit detailed consideration.

4.08 The full evaluation of alternatives for keeping the Murray mouth open, carried out by the Sand Pumping Technical Committee in 2002 must be made public to properly inform the policy process. Some of these options, while appearing to be more costly than dredging appeared to be in 2002, may prove to be valuable contributors in a combined approach. For example;

"The Southern Alexandrina Business Association[19] has sent (9/04/09) **a proposal to SA Water Security Minister Karlene Maywald for a break-water for the neighbouring Coorong. Association president John Clark says the cost would be roughly the same as dredging but would have longer-term benefits for the internationally-recognised Coorong wetlands".**
http://www.abc.net.au/news/stories/2009/04/09/2540147.htm

If the local Business Association's costing is anywhere near the reality then a mix of pipes, dredging and breakwaters is likely to be even more effective than each option in isolation. And the cost is certain to be substantially less than the MDBA's perverse fresh water fetish.

5.00 Alternatives:

5.10 **The Buyback of 3 million ML of irrigation water to maintain a higher continuous outflow.** This option has a total cost in the order of $6 billion, with annual costs of $600 million. It uses high value, and highly variable supplies of fresh water to do a simple hydrological function. It wastes more than half the total volume supplied because it is delivered at a time when there is next to zero assistance in sand removal from tidal outflows.

5.11 It is incapable of responding in the time and scale needed to deal with the key storm surge deposition events. It is a continuous, static solution to a set of dispersed, variable impacts. And it will not alter the fact that the capacity of the tides to fill-in the Murray mouth is in direct proportion to the degree to which the river flows might open it.

5.12 In economic terms it is an even bigger waste. It takes water that is currently put to profitable use in an important national value chain. It involves water that must be purchased at considerable cost to the Commonwealth and it involves a significant ongoing reduction in the tax base and a serious undermining of the cost base for major storage infrastructure like Dams etc.

5.13 It will achieve little additional benefit to what has been delivered by a single dredge for the past three (worst case) years at an annual cost of $2.33 million.

5.14 And none of the wealth transfers involved appear to be incorporated into the Commonwealth Grants Commission processes, the body responsible for the fair and equitable distribution of Commonwealth funds between the states.

5.15 And it will not go anywhere near to restoring the ecological values of the lower Coorong, the very wetland used to justify the use of this water.

5.20 **Removal of the Barrages to restore the tidal prism.** This option has been promoted as the obvious solution to the major evaporative losses that take place within the lower lakes in severe drought.

5.21 But in a context of a current 5 million ML mean annual discharge of fresh water out the Murray mouth, and the prospect of an additional 3 million ML from buy-backs for the same end, the increase from a pre-settlement 400,000 ML fresh water evaporation to a current 500,000 ML net figure, makes this very much a second order issue.

5.22 The contribution of partial openings during drought to maintain internal water levels etc is certainly an option that needs proper consideration.

5.23 However, the permanent opening of the Barrages will actually exacerbate problems of excess deposition in the mouth by increasing the volume and velocity of the tidal inflows.

5.30 **The construction of open channels through the dunes to introduce more sea water into the Coorong Lagoons**. This option would be comparatively cheap to implement but would be quite short lived. If the Murray mouth, with its additional discharges of fresh water, cannot combat the internal sand build-up from tidal inflows and storm surges then additional man made channels will be closed by the same forces in even less time. Open channels must function in the same littoral zone as the Murray mouth and the resulting exposure to the forces at play in that zone would require continual maintenance expenditure and render the option unviable.

5.31 The closure of open channels would take place even faster if gates were fitted to allow for unidirectional flows.

5.40 **The installation of large diameter, in-flowing pipes under the dune system to the Coorong,** one supplying the North Lagoon and two supplying the South Lagoon, each delivering approximately 100,000 ML of sea water each year, sufficient to produce a net flow along the full length of the system and ultimate discharge through the Murray mouth.

5.41 The two, located near Fig Tree Crossing, would be capable of replacing all annual evaporation losses and, within a single year, push the entire hypersaline volume into the North Lagoon. The third pipe, just north of the Narrows, could then push the remaining volume out through the Murray mouth.

5.42 It is the first step in restoring the essential ecological values, especially normal salinity levels, to the system. The reliance on “tidal sloshing” has proven to be a consistent failure, especially for the South Lagoon. The delivery of fresh water from the Murray to the most useful parts of this system cannot be achieved without considerable additional capital outlays. And the volumes required cannot be sourced from the Upper South East Drainage Scheme.

5.43 This option substitutes a comparatively small amount of cheap, well targeted, sea water for a very large and indeterminate volume of expensive, poorly targeted fresh water that does not even perform the function assigned to it.

5.44 With this direct injection of tidal water into the Coorong system the full suite of environmental values and ecosystem services can be maintained with a substantially higher level of certainty. And the system can be maintained in a circumstance that remains connected too, but is no longer dependent on, the vagaries of Murray mouth hydrodynamics.

5.45 If the overriding aim of the MDB Guide’s requirement for 3 million ML of expensive buy-back water is to keep the Murray mouth sufficiently open so tidal sloshing might keep the Coorong ecosystem just above the point of ecological collapse then the need for this entire mouth open objective can be negated by just 300,000 ML of cheap sea water delivered directly to its point of maximum benefit.

5.46 The capital buy-back value of fresh water is $2000 per megalitre so the opportunity cost of a pipe that delivers 100,000 ML of sea water to do a better job is $200 million. Any capital outlay less than $600 million on these three pipes represents good value. Given that the concrete in a 1000m pipe of 3.6m diameter and 20cm thick only amounts to 2,400m3, and costs only $720,000 at retail prices, one must conclude that it would take some seriously monumental departmental bungling to push the installed cost above $100 million a pipe.

5.47 This option serves the first two functions outlined at 2.46 above, that is;

- **As a simple source of fresher water to overcome seasonal hyper salinity and replace evaporation losses in the closed end system.**
- **As a general augmentation of existing volumes into the far reaches of the Coorong to produce an increase over normal water levels and create a net outflow which will discharge excessive and unsustainable saline build-up out through the river mouth.**

5.50 The provision of additional pipes under the dunes either side of the Murray mouth to improve the management of normal flows and to respond in time and scale to retard the impact of storm surge deposition events.

5.51 These would need to be in sufficient number to deliver half the total tidal prism that would result from the onset of a 0.5m storm surge during the nine hour inflow phase of a 1.1m peak tide or 16 ML/ha. The total inflow would be 13,000 ML so the capacity of the pipes must be 6,500 ML over the same period to ensure that the volume flowing out the river mouth is double the volume flowing in the mouth.

5.52 Unlike pipes flowing into the Coorong where the outlet water level remains near AHD, pipes near the mouth would start inflows from the moment the low tide turned, and would continue to the tidal peak. The water velocity and discharge rates would be defined by the slope obtained from the water levels on either side of the dunes. And in the absence of more detailed analysis we should assume this to be a drop of 0.1m over 700m of pipe.

5.53 This would discharge 9.5m3/sec, or 34.2 Ml/hour, or 308 ML over a nine hour tidal inflow. The 6,500 ML capacity in that circumstance would require 21 pipes. This would mean one pipe for each 39ha of tidal area so the Goolwa channel would need 8 while the Tauwitcherie channel would need 13 pipes.

5.54 This would reduce the storm surge flow through the mouth to the same volume as a modest 0.8m tidal flow under natural conditions. A normal peak tide of 1.1m range would produce the even more modest 0.55m tidal inflow through the mouth with the full 1.1m outflow.

5.55 This across the board halving of river mouth inflow volume and velocity would produce a much more than proportionate decrease in sand deposition. The increase in river mouth outflow volumes and velocity through improved efficiency of the tidal prism would also produce an increase in sand disposal. And this gives us strong grounds for suspecting that this number of pipes may be significant over-kill.

5.60 Maintain dredging in a post flood open Murray Mouth. Once the mouth is open, it is an incontestable fact of history that a single dredge was able to maintain that open mouth during a period of zero fresh water discharges at a cost of only $2.33 million a year. The current capacity to move a minimum of 2000 m3 of sand in a 24 hour day along a pipeline up to 2km in length, is an asset that could be used elsewhere in the estuary to enhance the tidal prism. The sand bank just outside the Eastern end of the Tauwitcherie Barrage is a good first candidate and modification of The Narrows would also be justified. A system of pipes and breakwaters may produce additional need for dredging too.

5.61 It is obviously more economical to prevent a channel from degrading than it is to open a channel that has already closed. The current flood discharges have already opened the channels much wider than the dredge ever could but in subsequent years this maximum opening must contract. In a $10 Billion budget with $1 billion annual outlays, this $2.33 million punches well above its weight.

6.00 Conclusions

6.01 The option that least serves the purposes of the *Water Act 2007* is option 5.20 Removal of the Barrages. The restoration of the original tidal prism may provide a temporary improvement in tidal sloshing into the North Lagoon but this would be a very short lived improvement as the asymmetric tidal patterns will increase deposition at the Murray mouth and substantially retard the efficiency of that enlarged tidal prism. Any benefits to be gained by introducing sea water into the Lower Lakes during drought can be achieved by simply opening the Barrages. Their removal is not necessary.

6.02 Option 5.30 Construction of open channels to the Coorong does not serve the purposes of the *Water Act 2007* any better. The benefits of direct injection of sea water into the hypersaline ecosystem would be very short lived as the same processes at play at the Murray mouth would close any open channels even faster. This option would require continual maintenance at great expense.

6.03 Option 5.10 the buy-back of 3 million megalitres to increase regular flows is a static, continuous response to a variable, intermittent need. It also demands the scarcest and most valuable water to do a simple hydrological task that can be done better by cheap, abundant and reliable sea water. The scientific community has made no secret of their view that the volume is totally inadequate for the requirement. But the need to balance ecological, social and economic values for the up-stream communities will ensure that the required amount will not be forthcoming.

6.04 Option 5.60, Dredging, has already demonstrated its capacity to maintain an open Murray Mouth, at very low relative cost, and in worst case river flow circumstances. It has clearly earned the right to be included in any mix of solutions and is entirely compatible with other options as an outcome multiplier.

6.05 Option 5.40, Pipes under the dunes to the two Coorong lagoons, deals directly with the need to restore and maintain ecosystem services by delivering sufficient volume of fresh, fully oxygenated sea water to the exact locations that will meet the obligations under the *Water Act 2007*. It does so in a way that is in direct proportion to the need and it considers the highly relevant matters of timing, flow direction, adequacy and efficacy of water volumes delivered. It maintains the ecological integrity of the whole system but with a fully flexible stand alone management system. It operates in an incremental framework that deals with the most pressing ecological problem, South Lagoon hypersalinity, first and can then play its part in the broader issue of maintaining the Murray mouth.

6.060 Option 5.50, Pipes under the dunes to manage the Murray mouth, becomes a lesser priority once the ecological integrity of the Coorong has been restored by Options 5.40 and 5.60. The health of the Coorong need no longer be dependent on the state of the Murray mouth.

6.061 However, any pipes near the mouth will be better than no pipes because every pipe will enhance the contribution already made by river flows. The economics of trenching and subsequent dune restoration dictate that three or four pipes should be installed in each excavation. And the need for balanced hydrology in both channels would demand a minimum of eight pipes with four on each channel. The reality is that sea water is a superior, more abundant, lower cost, less disruptive and more proportionate substitute for all fresh water discharges through the Murray mouth. And there is no excuse for not doing so.

6.062 If the Australian community has already accepted a budget in excess of $6 billion for the buy-back then the mandate is already in place to spend up to the same amount on pipes to do a much better job.

6.063 When that $6 billion opportunity cost of the 3 million megalitre buy-back is spread over the estimated 16 pipes needed to completely restore the Coorong and keep the Murray mouth wide open we get an extraordinary $375 million for each pipe. The $200 million/pipe figure used in 5.46 above does not factor in the improved water use efficiency delivered by proportionate sea water over disproportionate fresh water.

6.064 And given the savings to be gained from placing 3 or 4 pipes side by side in the one excavation we can safely conclude that the cheapest and best option is undoubtedly the pipes.

6.065 In fact, with the Barrages in place for more than 70 years now, the demarcation of sea and fresh water ecosystems is well established. And this means that further substitution of sea water for existing flows is also feasible as a source of additional fresh water for up-stream wetlands. With adequate sea water systems in place there is no longer any justification, either logical or ecological, for a single drop of fresh water to go over the Barrages. All of existing fresh water outflows (up to 5 million ML) could be used for delivery of up-stream ecological services at zero cost to the economic, social and ecological values of the Basin.

6.066 **I advise accordingly, and request that the MDBA considers all relevant matters outlined in this submission, and takes all reasonable and practical steps, to ensure that it does not;**

- **give effect to any improper exercise of power, or**
- **apply measures that are not cost effective, or**
- **apply disproportionate measures, that may**
- **cause entirely foreseeable, and avoidable detriment to people or communities in the Murray-Darling Basin.**

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