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Ms Siobhan Leyne
Inquiry Secretary,
Inquiry into the impact of the Murray-Darling Basin Plan in Regional Australia,
Standing Committee on Regional Australia,
PO Box 6021, Parliament House, Canberra. ACT. 2600. ra.reps@aph.gov.au

Dear Ms Leyne,

Inquiry into the impact of the Murray-Darling Basin Plan in Regional Australia.

Thank you for your letter advising that my submissions (Synopsis of a water allocation procedure, Principles of water allocation and an extract from a paper by Aloni (1970)) have been received by the Standing Committee on Regional Australia. I had not sent the submissions directly to the Inquiry but had sent copies to Hon. Tony Windsor, Hon. Tony Burke and Mr Bob Freeman (MDBA) among others, so I would be glad if you would advise me which of these forwarded the submissions to the Inquiry.

I have since had some feed-back from my initial papers and have made several minor changes to the next versions (mainly to make them more readable), so I will attach the revised versions to this email as my direct submission to the Inquiry.

I had proposed to circulate the papers to a number of other interested parties before seeking formal publication, but I would be quite happy for the versions that I now enclose to be my formal submission to the inquiry and to receive the protection of Parliamentary privilege and to be published on the Committee’s website. I regard the papers as a ‘work in progress’ and would look forward to receiving comments which could lead to changes in the ‘final draft’.

Comments that I have received to date suggest that there may be some virtue in re-visiting Section 100 of the Australian Constitution which is mentioned briefly in one submission (Principles of water allocation). About 10 years ago, I prepared a paper on Groundwater Law and showed it to a Law Professor but had not taken it further because of the need to first establish the significance of baseflow in Australian landscapes. This has now been done so I am rewriting the Groundwater Law paper and feel that it, too, should be considered by the Inquiry into the impact of the MDB Plan. I plan to submit it in the next few days as a separate submission.

I would be glad to receive a hard copy of the report you mentioned in your email.

Thank you again for your reply and I will look forward to the Committee’s comments with much interest.
Yours sincerely,

Jim Galletly.
Agricultural Ecologist.

Synopsis of a water allocation procedure

J.C. Galletly

Summary

For a water allocation procedure to be adopted, it must enable 'mutual coercion, mutually agreed upon', so it is essential that it is clear, transparent, just and readily understood by the water users involved, i.e. by all the people in the Basin. Mutual coercion must act by making aberrant behaviour unremunerative rather than criminal and there must be ample means available for those aggrieved to challenge the system. The essential features are:

1. Measure all water use to determine whether or not use is 'reasonable'.

2 and 3. Measure depth of water in aquifers to determine whether water levels are steady, rising or falling. Establish historical streamflow durations in the 'pre-irrigation' period and determine a 'reasonable' (target) streamflow duration (days/annum) near the sub-catchment outlet. Compare this with the actual current streamflow duration and use these (aquifer and streamflow) measurements to determine whether the current level of water use is too high or 'reasonable'.

4 and 5. Estimate the size of the long-term consumptive pool of water available for use in the sub-catchment and the net present sustainable yield (ML/annum), on the basis of current rainfall and the measurements made in (2) and (3) above.

6 and 7. Determine the area (ha) of good quality agricultural land (GQAL) in the sub-catchment; prepare farm plans for the commercial irrigation farms and determine the area of GQAL used for irrigation farming.

8. For the whole sub-catchment, allocate the net present sustainable yield (ML/annum) to the area of good quality agricultural land used for irrigation farming as ML/ha for the forthcoming year.

9. Determine the allocation to each farm as the area of GQAL (ha) used for irrigation on each farm (from (7) above) multiplied by the water allocation (ML/ha) (from (8) above). A charge ($/ML) would be levied for water actually used. Each farmer would decide how to use the water allocated to each farm. The allocation would be made one month prior to the start of the water year in each sub-catchment.

10. A Water Tribunal would be established in each sub-catchment to enable each step in the procedure to be challenged by those aggrieved by administrative decisions.

It may take a few years to finalise all details of the procedure in each sub-catchment but it should then be possible for the system to work indefinitely and sustainably.

Synopsis a of water allocation procedure

J.C. Galletly

Abbreviations:

AWD – Aquifer water depth – m
RWD – Reasonable (aquifer) water depth – m

AFD – Actual streamflow duration – days/annum (days/a)
RFD – Reasonable streamflow duration – days/a
LTCP – Long-term consumptive pool – ML/a
C-NPSY – Sub-catchment net present sustainable yield – ML/a
GQAL – Good quality agricultural land - ha
I-GQAL – Area of irrigated good quality agricultural land in the sub-catchment area – ha
CWA – Sub-catchment water allocation – ML/ha/a
FWA – Farm water allocation – ML/ha (for the forthcoming year).

1. **Measure all water use** for all purposes, to determine whether or not use is 'reasonable', as required by the Australian Constitution, Section 100.

2. **Measure depth of water in aquifers.** Estimate average depth **(AWD – Actual Water Depth - m)** of water in aquifers in the sub-catchment and determine whether it is steady, rising or falling. In general, if it is rising, water use could increase; if falling, it should decrease. Make a preliminary, tentative estimate of the **'reasonable water depth' (RWD - m).**

3. **Measure streamflow duration.** For the pre-irrigation period (say, pre-1950), determine the relationship between annual water year rainfall and duration of streamflow near the sub-catchment outlet, and determine a '**reasonable' flow duration' (RFD – days/annum)** for given rainfall ranges. Measure the current 'actual flow duration' (AFD) near the outlet of the catchment. If it is less than RFD, water use should be reduced, and if greater, water use could be increased.

4. **Estimate the size (volume) of the long-term consumptive pool (LTCP – ML/a).** The consumptive pool is the volume available for allocation for 'consumptive use' (as distinct from 'natural use'). This is the pool volume when the aquifer water level is steady and the streamflow duration is equal to or greater than the RFD. The size will be refined with experience over time.

5. **Estimate the Catchment Net Present Sustainable Yield (C-NPSY – ML/a)**. This is the yield (level of extraction) at which aquifer water levels are optimum or rising and the actual streamflow duration is equal to or greater than the RFD. If water levels or stream durations are less than optimum, the C-NPSY is less than the LTCP (estimated long-term consumptive pool) and vice versa. In any given year, C-NPSY varies with rainfall and changes are made each year, proportionally, 'across the whole sub-catchment'.

6. GQAL. Determine area (ha) of **Good Quality Agricultural Land (GQAL)** in the sub-catchment using the best available soil map. (Update the map if necessary.)

7. Farm Plans. Prepare farm plans of the current commercial irrigation farms. These are the farms eligible to receive a share of the C-NPSY of the sub-catchment. From the farm plan of each, determine the area of GQAL on each farm used for irrigation farming (I-GQAL). The sum of these areas gives the total area of Irrigated GQAL (I-GQAL – ha) in the sub-catchment.

8. Catchment Water Allocation (CWA - ML/ha). Allocate the C-NPSY to the I-GQAL as ML/ha for the whole sub-catchment for the forthcoming water year. This is the C-NPSY (ML/a) divided by the I-GQAL (ha).

9. Farm water allocation (FWA - ML). From the farm plan I-GQAL (ha) and the sub-catchment NPSY, (C-NPSY ML/a) calculate the Farm Water Allocation (FWA - ML) for the forthcoming year as Farm I-GQAL (ha) multiplied by the sub-catchment C-NPSY (ML/ha). The allocation is made one month prior to the commencement of the water year in each catchment.

10. Water Tribunal. A Water Tribunal would be established in each sub-catchment to enable each step in the procedure to be challenged by those aggrieved by administrative decisions.

The arithmetic (as an example).
Depths: RWD = 12 m, AWD = 7m.
Flow durations: RFD = 250 days/a; AFD = 150 days/a
Estimated Long-Term Consumptive Pool (LTCP) = 50 000 ML/a
Estimated Catchment Net Present Sustainable Yield (C-NPSY): (7 m, 150 days, hence, less than LTCP): say, 80% = 40 000 ML/a.
Total GQAL in catchment = 120 000 ha
I-GQAL on 90 farms = 65000 ha
Catchment NPSY = 40000 ML/65000 ha = 0.62 ML/ha
Farm Water Allocation for a farm with 500 ha I-GQAL: FWA = 500 x 0.62 = 307.69 ML

Notes on synopsis of a water allocation procedure.

1. Measure all water use. The only way to manage water to determine whether or not use is reasonable (as required by the Australian Constitution, Section 100) is to measure it. This has not been done in the past, hence our current predicament. Those who oppose measurement are either not professional irrigation farmers or have something to hide. We must measure all water use from lakes, streams and aquifers to determine how much useable water we have, where it is, who is using it and for what purposes. Essentially we must measure all water use except that from domestic water tanks.

2. Measure depth of water in aquifers. To date, depth of water in aquifers has not been measured so the relationship between stream level and aquifer water level and the slope on the water table has not been measured. This has allowed so-called ‘managers’ to pretend that aquifer management is difficult and complicated but that they ‘understand’ aquifers. This ‘understanding’ is based on descriptions of aquifers in other continents, climates and landscapes which have little relevance to alluvial aquifers in Australia which are recharged by baseflow rather than by rainfall. In many districts, the existing bore monitoring network is sufficient for initial estimates of depth. These will be revised over time using more bores and better data.

3. Measure streamflow duration. These data are already available for many streams and are sufficient to determine what was a ‘reasonable’ streamflow duration prior to the advent of irrigation (perhaps in the 1950s) and also in recent years. In the years before irrigation began, streamflow was sometimes continuous or at least over 300 days/a; the long-duration dry-season flow being baseflow: outflow from basalt (or other) aquifers high up in the landscape. This provided the ‘permanent water’ for stock and so was the basis for the western pastoral industries. Those managers who favour dams would prefer to have us believe that surface runoff is homogeneous, comprising overland flow only which, if not used for irrigation is ‘lost to the ocean’ or just wasted downstream.

This is not so, and in the Murray-Darling Basin, most overland flow events are of quite short (10 – 20 days) duration and it is often difficult to use much of this water in the catchment in which it is generated. Floodplains spread this water widely and most pastoral industries and wildlife wetlands rely on overland flow to provide feed for stock and habitat for survival and in this sense, they are ‘environmental flows’. Baseflow is also an important environmental flow which ensures the maintenance of riparian vegetation and thus the stability of stream banks and it is also the economic flow which recharges the aquifers under the alluvium from which water is extracted for stock and irrigation. Thus, there is no conflict of interest between economic and environmental concerns in maintaining the duration of baseflow which confers many benefits to both upstream and downstream water users.

In the past, many ‘managers’ have refused to consider baseflow (see the current MD Basin Plan) on the basis that it is a small, minor component of surface runoff and so could not possibly make a significant contribution to aquifer recharge. It is true that baseflow is often less than 25% of flow, but it does continue in many years when there is no overland flow and, over the past 10 000 years (since the last Ice Age) it has had ample time to recharge the alluvial aquifers from which water has been extracted as if it was a ‘magic pudding’. We must now face the reality of the recharge mechanism of these aquifers as shown by Australian, rather than by American data. We must ensure that, even if significant proportions of overland flow are harvested, natural baseflow volume and duration is maintained.

4. Estimate the size of the long-term consumptive pool. In an ideal world, this would have been measured years ago, but we must make our estimate now on the basis of flimsy evidence. As a start, we need to identify the source(s) of water in each catchment and measure the ‘catchment yield’ in each and use this as our initial estimate of the consumptive pool. After all water use has been measured for a couple of years, the average water use could be seen to indicate the size of the consumptive pool. If this level of water use continues and if the aquifer water levels continue to fall, then obviously, the estimate is too large and further cuts are required (and vice-versa). After a few years of measurement and adjustment, we should begin to get close to an accurate estimate, but we must accept that it is not accurate at the present time.

5. Estimate the sub-catchment Net Present Sustainable Yield (C-NPSY). Irrespective of what happened in the past, it is the present that is important. The decision on the size of the current catchment NPSY is best taken by a local representative committee on the basis of the depth of water in aquifers as compared with the ‘reasonable’ depth, and the duration of streamflow compared with the ‘reasonable’ duration. The C-NPSY chosen should be on the basis of rising or falling levels and by how much. There are no ‘rules’ to guide this judgment. If levels are falling and the local community does nothing, it means that it wishes to eliminate itself. There may need to be safeguards so that, in that situation, the government could step in and nominate a reduction. The important thing is that the mechanism must be transparent and preferably widely understood so that a ‘reasonable’ decision can be taken.

An important characteristic of the C-NPSY is that it applies ‘over the whole sub-catchment’, so that we do not have the continuation of a system in which the allocations to some farmers are reduced and others are not. Indeed, in some places, the ‘high water users’ (who have caused the over-allocation problem) are rewarded with even higher allocations, while the ‘low water users’ (the prudent water users) are penalised. This, surely, is blatant corruption and must not continue.

6. Identify good quality agricultural land (GQAL). In Australia, water is the limiting resource, not land. It follows that it is ‘reasonable’ to use our limited water resources only on areas which will provide most benefit in terms of food/fibre production per ha as demonstrated by $/ML. Soil survey procedures for identifying GQAL are well established and should be followed in the MDB.

7. Farm Plans. Farm planning procedures are well developed in Australia (especially for irrigated areas in Victoria and for soil conservation in Queensland) and make good use of soil maps. Local people are probably best placed to prepare a list of commercial irrigation farms in the sub-catchment and, if there is doubt, this can be checked on aerial photographs. Having prepared a farm plan of each commercial irrigation farm, the area of irrigated GQAL on each farm can be determined and the sum of these gives the catchment I-GQAL (ha).

8. Sub-catchment Water Allocation (CWA - ML/ha). It has been demonstrated over recent weeks that this step generates much heated argument in almost all of the sub-catchments of the Murray-Darling Basin. It is suggested that this situation exists because the system currently used to allocate water is unjust, unfair, inequitable, unreasonable and unable to be justified on social, political, constitutional, economic, scientific, ethical or legal grounds. It is argued that the model outlined here can be justified on all these grounds. Having completed steps 1-7 above, the catchment allocation is simply the Catchment NPSY (ML/a) divided by the total Irrigated GQAL in the sub-catchment. No doubt, there will still be some arguments about the size of the CWA so a Water Tribunal should be established in each sub-catchment as explained in step 10 (from the Water Laws of Israel' (Aloni 1970)) where reasoned argument can be advanced against an allocation, defended by a representative of the 'Water Commissioner' and adjudicated quickly and at little expense by a Tribunal with qualifications in Law, Irrigation Practice, and the Local Situation.

9. Farm Water Allocation (FWA – ML/a). Having completed the above steps, the water allocated to each farm for the forthcoming year is simply the I-GQAL (ha) on the farm multiplied by the C-NPSY (ML/ha/a). The allocation is made one month prior to the commencement of the water year in each catchment. (The timing of the water year may not be constant throughout the Basin.)

10. Water Tribunal. It is critical for the administration handling water matters to give the widest opportunities to the public, insofar as it considers itself aggrieved by the decisions of the administration, to present its criticisms and to object to any or all of the above steps. This will be facilitated by the establishment of a Water Tribunal in each sub-catchment to serve as a Court of Appeal against administrative decisions, along the lines of that which operates in Israel (Aloni 1970) (see attached extract). It is argued that the system which applies there greatly facilitates water management and reduces considerably the need for application to the said Tribunal.

Glossary

Aquifer. A saturated, permeable geological unit that can transmit significant quantities of water from place to place under ordinary hydraulic gradients, enabling economic development.

Aquifer mining. The process, deliberate or inadvertent, of extracting groundwater from a source at a rate so that the groundwater level declines persistently, threatening actual exhaustion of the supply.

Baseflow. Natural, prolonged, clear, surface outflow of rain water from groundwater aquifers in specific geological strata adjacent to or upstream from an observation point.
Catchment water allocation (CWA). The volume of water allocated for consumptive use in a catchment or sub-catchment in a given year as ML/ha/annum.
Long-term Consumptive pool (LTCP). The volume (ML/annum), of water in a catchment available for extraction for consumptive use (evapotranspiration) at which aquifer water levels are stable or steadily rising.
Evapotranspiration. A combination of evaporation from open bodies of water, evaporation from soil surfaces and transpiration from the soil by plants.
Good quality agricultural land (GQAL). Land which has been classified as good quality agricultural land on the basis of accepted soil survey data. (I-GQAL is good quality agricultural land used for irrigation farming).
Hydraulic conductivity. The rate of flow (m/s) in porous materials in response to a unit hydraulic gradient (slope on the water table of 1 m vertical in 1 m horizontal).
Hydrology. The science which deals with movement of water through the hydrologic cycle by various hydrological processes, especially rainfall, infiltration, soil storage, evapotranspiration, deep percolation, groundwater flow and surface runoff: overland flow, interflow and baseflow.
Infiltration. Movement of water into the surface of soil.
Net present sustainable yield (C-NPSY). The yield of a catchment (or sub-catchment) which, in the short term, results in a slight rise in aquifer water levels. The C-NPSY is usually slightly less than the ‘safe yield’, given the depleted state of many aquifers.
‘Reasonable’ (decision, argument): that which can be defended by sound reasons.
Running water. Water which continues to flow for a prolonged period of time after a heavy rainfall event: i.e. baseflow (rather than stormflow which flows intermittently).
Safe yield. The yield (level of water extraction) from an aquifer or catchment at which, in the long term and under similar rainfall conditions, aquifer water levels are steady and the streamflow duration is virtually constant.
Saturation overland flow: Streamflow generated after sufficient rain has fallen to saturate either the whole of the soil profile or a surface horizon underlain by a relatively impermeable horizon.
Stream mining. Extraction of water from a stream to the extent that streamflow duration is diminished and does not recover after the next wet season.
Transmissivity: The rate of water movement (m/day) through an aquifer segment, 1 m wide; the product of hydraulic conductivity (m/day) and depth of water (m) in the aquifer.

Jim Galletly PhD, MAgrSc, QDA

Principles of water allocation

J.C. Galletly

In 2008, a memorandum of understanding about water management in the Lockyer Valley was developed by Jim Galletly for presentation to the Queensland Government and other interested parties. The reason for the memorandum was that, to date, water resources had been grossly mismanaged because the hydrology of the water supply was not understood. Groundwater use for irrigation was not regulated so the initial store of water in downstream alluvial aquifers was steadily depleted and many areas had reverted to dryland agriculture. It was proposed that a new management system was required to enable profitable irrigation farming to be sustained well into the future and the memorandum set out a procedure to explain how this objective could be achieved.

It is now recognized that the Lockyer Valley is a microcosm of the numerous small headwater catchments on either side of the Great Dividing Range in eastern Australia where a largely sedimentary (sandstone) landscape has a basalt lava cap and an alluvial valley floor with fertile soils derived from basalt. Aquifers in the layers of vesicular basalt receive and store rainfall temporarily and discharge it from springs to produce baseflow in creeks which, in turn, recharges the alluvial aquifers on the valley floor. There are certainly many areas with similar landscapes (with similar climate, geology, soils, vegetation and wildlife) in the Murray Darling Basin and it is likely that, in these, the Lockyer pattern is repeated. In others, baseflow may be discharged from sandstone or limestone aquifers. It is likely that baseflow is the main source of aquifer recharge in the Murray Darling Basin while overland flow supplies surface storages. On this assumption, the following are the important premises on which allocation of water in the various sub-catchments of the Basin should be made.

Principles

1. Land. The soil and water (land) resources of Australia are public property, under the control of the Commonwealth and/or States, and intended for the needs of its residents and the development of the country’s economy (Aloni 1970, Hillel 1991). Current landholders are the temporary custodians of land and must manage it in the best interests of present and future populations.

2. Soil. The basic principle of soil conservation is to ‘use every piece of land according to its capability and treat it according to its needs’. Land which is not capable of responding adequately to additional water should not be irrigated because water is the critical, limiting resource. Methods have been developed for classifying land for a range of purposes including agriculture and only good quality agricultural land (GQAL) should be used for irrigation farming.

3. Water. Water is one of the five fundamental elements (earth, air, fire, water, wood) and is a vital component of land. Management of water must recognize this important fact. Therefore, permanent water trading, which separates water from land, must be abandoned. Water is a mobile substance and the quantity provided by the climate to a specific area varies widely from place to place. The rain which falls in one place may provide water to distant places downstream.

4. Land ethics. Water availability is a prime determinant of land use and to date water allocation has been seen as solely an economic problem, concerned with the regulation of trade and commerce. For this reason, many have misunderstood the meaning of the phrase 'reasonable use of water' in the Australian Constitution (see Note, Section 100). Water allocation is primarily an ethical question and an allocation is ethically correct if it tends to preserve the integrity, stability and beauty of the biotic community (including mankind) which depends on the land for which the water allocation is made. To allocate water effectively, each situation must be examined in terms of what is ethically and aesthetically right as well as what is economically expedient in the short term (Leopold 1949). An allocation is right when it tends to preserve the integrity, stability and beauty of the biotic community. It is wrong when it tends otherwise.

5. Economics. With water, as with money, we must now learn to live within our means, and not use more than our fair share of this common resource. It has been clearly demonstrated that 'free market forces' are not able to manage the money supply, let alone water or anything else. Therefore, it must not be assumed that market forces could manage water supplies effectively. Governments must manage water as implied in the Australian Constitution. From an economic point of view, the central concept of wisdom is permanence (Schumacher 1974). We must study the economics of permanence. Nothing makes economic sense unless its continuance for a long time can be projected without running into absurdities. There can be growth towards a limited objective but there cannot be unlimited, generalized growth. It is more than likely, as Gandhi said, that 'Earth provides enough to satisfy every man's need but not for every man's greed'. The Australian Constitution does not recognize this principle.

6. Running water. Running (or moving) water in rivers and in groundwater is not able to be 'owned' by individuals. (This has been a basic tenet of Roman Law since Justinian, 529 AD.) They are common resources in public ownership, and management of these resources is vested in the Commonwealth and/or States. Every free Australian citizen has a right to his/her reasonable share of the water resources of the nation as guaranteed by the Australian Constitution. Governments have the responsibility to ensure that the available water resources are used efficiently and distributed equitably and justly according to legal principles.

7. Distributive justice. In assessing the justice of a particular water allocation, the principles of distributive justice, in accordance with geometrical proportion as set out by the Greek philosopher Aristotle (Ross 1998, pp. 109-114) should be followed. Rainfall affects both streamflow and aquifer recharge and it varies from year to year so, in general, water allocations must vary accordingly. Each irrigation farmer is entitled to a share of the available water as a proportion of the total. Allocations should be made as mega-litres per hectare (ML/ha) of land irrigated and when allocations change with rising or falling streamflows or aquifer water levels, the changes must apply to all allocations equally (Aloni 1970). If the proportion of water to be allocated to each hectare is unequal, it is unjust, for the just is equal. Thus, the proportion of water allocated to each hectare will change from year to year, but in any year, the changes will apply equally to the whole area (catchment or sub-catchment).

8. Priority. In general, domestic use of water takes precedence over other uses, followed by water use for human food production, for livestock, other uses for industry and irrigation, and other non-essential uses. Water use for domestic purposes from rivers and groundwater was well established prior to the development of irrigation and so domestic water users must be regarded as the 'prior (senior) appropriators' of water (in the American sense), even though formal agreements were not drawn up when water use began (as was the case in the US in the 1850s). Likewise, water use for the irrigation of important community high-use areas such as schools, show grounds, parks, gardens, and sports fields are high priority water use areas.

There is no particular virtue in using irrigation water to grow feed for racehorses as the racing industry was well established prior to the advent of irrigation. This is not to imply that lucerne should not be grown; only that, if it is, the water allocation (as ML/ha of GQAL used for irrigation farming on that farm) must be the same as that of other farms. It must not be greater than others, thereby depriving others of their fair share of the resource and their livelihood. Likewise, the situation whereby water use of some farmers is measured and charges for it are levied (as in the Central Lockyer) while water use of others (as in the Upper Lockyer) is not measured and no charges are levied, must be abandoned.

Also, there is no sense at all in using irrigation to grow crops or stock for export if the export price does not cover the actual cost of the water used (which may be quite high). Such exports comprise exporting ‘virtual’ water or the ecological capital of the nation (Barlow 2006).

9. Stream and aquifer mining. Stream and aquifer mining (using surface water and/or groundwater at a greater rate than the rate of recharge) are serious forms of land degradation and must be brought under control forthwith. They destroy, not only the current productive capacity of land but have the capacity to damage the stability, integrity and beauty of river systems and the recharge capability of aquifer systems, so that they may have long-lasting effects, perhaps for tens or hundreds of years. If we have any respect for our children’s future, we must stop aquifer mining immediately. Mining is incompatible with the notion of permanence.

10. Correlative use of water. There are several important ‘doctrines’ which form the basis of Groundwater Law, one of which is the ‘Doctrine of Absolute Ownership’ which has now been largely displaced by one of the many variants of the ‘Doctrine of Reasonable Use’ (use which can be justified by reason). One of the important variants of the doctrine of reasonable use is the ‘Doctrine of Correlative Use’ which holds that, where several landholders extract water from a common aquifer, their use is co-related: i.e. use by one landholder affects that of the others. The reason for this is that it is impossible to extract water from under *only one* property. In an aquifer, water is continually moving, albeit slowly, and movement is driven by the gradient on the water table. If one landholder pumps more than others, a ‘cone of depression’ forms under his land and water flows to his pumps from all surrounding areas. For this reason, one cannot ‘own’ the water under a given piece of land but it is *reasonable* to take a share of the water stored in the aquifer, provided that the total taken does not exceed the current rate of recharge to the area. The time period over which this recharge takes place may be one or several years (or wet seasons) and in eastern Australia where rainfall variations are often determined by the ENSO (el nino southern oscillation) cycle, a major replenishment may occur only once in each four years. If the overall rate of extraction exceeds the rate of recharge for a significant period, aquifer water levels fall and an aquifer mining situation is said to exist. Conversely, in a series of wet years, the aquifer water levels may rise significantly as rainfall provides a greater proportion of evapotranspiration for plant growth. It is important to know the source and mechanism of recharge if the irrigation enterprise is to survive indefinitely.

11. Riparian doctrine. A long-standing aspect of water law is covered by the Riparian Doctrine which holds that all riparian land owners have a right to a share of the water in streams, so that both upstream and downstream riparian owners have similar shares for ‘natural use’, meaning ‘non-consumptive use’. (A riparian owner is one who owns land adjacent to a body of water.) The Doctrine was applied in England following the industrial revolution when water wheels were often used as the source of power for industries, and the doctrine ensured that the water supply to downstream users was not jeopardised by upstream use. When irrigation water use began in the eastern States of the US, the doctrine was modified to allow ‘un-natural’ consumptive use and it was then the right of riparian owners to take a share of the water in adjacent streams, according to the area (ha) owned and the volume allocated was in terms of ML/ha/annum, on the understanding that the total volume taken did not materially decrease the streamflow. This doctrine became known as the 'doctrine of reasonable use'. Some owners did not take up their allocation immediately, but when they did, the others would sometimes need to adjust their shares. This doctrine applies in some States in Australia but not in others (e.g. Victoria) where most riparian land became the property of the Crown in the late 1800s.

12. Freedom in a commons. The word 'common' according to the Oxford English Dictionary (OED 1964) has many meanings, the first of which is '1. Belonging equally to, coming from, or done by, more than one' and another interpretation is 'Land belonging to a community, especially unenclosed waste land' etc. It was understood in medieval Europe that all citizens had equal right to use common land and many evidently regard groundwater as a 'common' for which their right of use is unrestricted. Hardin (1968) discussed 'the tragedy of the commons' which results in the destruction of the productive capacity of land when too many people use common land too intensively. A similar scenario results when too many people extract too much water from aquifers or rivers. Hardin considered that this is one of a class of human problems which can be called a 'no technical solution problem': i.e. it is a problem with social and political aspects which must be tackled concurrently with technical aspects..

The solution proposed by Hardin is 'mutual coercion, mutually agreed upon'. We must insist that groundwater is not a commons and apply well-established principles of regional planning. The aquifers must be managed using mutual coercion, mutually agreed upon by the majority of people affected by the current lack of management. An alternative to the commons need not be perfectly just to be preferable. Injustice is preferable to total ruin. A model of 'mutual coercion, mutually agreed upon' has been operating in Israel in its irrigation system for at least 50 years (Aloni 1970) involving measuring all water use, equitable distribution of water, and levying a fee for all water use; a fee which escalates (as $/ML) for increased use. This could be used as a model for water management in the sub-catchments in the Murray Darling Basin.

13. The sub-catchment water supply. As with any other problem, correct diagnosis of the cause of aquifer and stream water mining is essential if the problem is to be redressed. In Australia, it has been common to attribute falling aquifer water levels and reduced streamflow duration to low rainfall or 'the long drought' rather than to extraction of water for irrigation. Hillel (1991, p. 153) describes a similar situation with the Ogallala aquifer in the US. For some decades the farmers of this region, instead of cooperating to regulate pumping regionally and to replenish the aquifer insofar as possible, have been competing in drawing water for their own immediate profit without regard for the region's future. Since water is a fluid and recognizes no property boundaries, any individual who attempted to conserve water was in danger of having his water pumped out from under him by his less scrupulous neighbours. And so, in a case of private enterprise carried to an aberrant extreme, the entire thriving irrigation district had been engaged compulsively in the exercise of putting itself out of business. A similar situation exists in the Murray Darling Basin in Australia.

A similar situation exists in the Lockyer Valley (and probably in many other valleys) where the situation caused by 'aberrant private enterprise' has been exacerbated by a complete misunderstanding of the source of the water supply for irrigation due to a failure to recognize the significance of basalt aquifers. It is now established that there are two sets of aquifers in the Lockyer Valley, linked by baseflow (Galletly 2007). One set is in the basalt lava cap on the Main Range in the west and south of the Valley and the second set is in the alluvium on the Valley floor. Part of the rain water which falls on the basalt country deep percolates to aquifers where it is stored temporarily and is then discharged over several months from springs to provide baseflow in creeks. It is the long-duration baseflow which recharges the alluvial aquifers on the Valley floor from which most of the irrigation water is extracted. Over the period 1910-2000, median baseflow was close to 25 000 ML/annum, the estimated volume of aquifer recharge (QWRC 1982).

Deep percolation is possible on the shallow, permeable, skeletal black earth (Vertosol) soils of the high, rugged basalt country but is precluded on the alluvium because the soils are deep and impermeable and have a high plant available water capacity (PAWC) which is greater than the quantities of rain which are able to infiltrate into the soil. This difference was not appreciated by those who managed the system since 1940. They believed that all aquifers were recharged by rainfall and that baseflow was actually outflow from the adjacent alluvial aquifers. As a result, in many places, aquifers have been mined to extinction. In some cases, there is now little chance of ever recharging these aquifers because of the low saturated hydraulic conductivity of the aquifer materials due to aquifer compaction; the reduced transmissivity of aquifers because of the reduced depth of water in aquifers, and the reduced baseflow volume and duration due to excessive upstream water extraction for irrigation and lower rainfall as a result of climate change.

In future, water management should be placed in the hands of those with a sound training in hydrology which is the central component of agricultural science, soil science and ecology. We irrigate because, in order to grow, plants must lose water by evapotranspiration, and after rainfall and infiltration, evapotranspiration is the major process of the hydrologic cycle. It is not the main focus of engineering training which concentrates on ‘flood hydrology’ (IE Aust. 1987). This principle must also be recognized in the Murray Darling Basin.

Conclusion. Water allocation is a difficult problem so long as it is regarded as solely an economic problem rather than a moral and ethical problem. In Australia, we have not yet come to grips with the idea that the water is our rivers and aquifers is a limited resource, partly because we do not accept that the main useable source is baseflow rather than overland flow. As a result, extravagant, unrealistic allocations of water that does not exist have been made. We must now move quickly to measure all water use and to develop an allocation procedure which is socially and politically acceptable, legally possible, and ecologically and economically sustainable in the long term. There is really no other alternative.

‘Cherish the earth and it will feed its people’ (Frankel, CSIRO).

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Note: Australian Constitution, Section 100.
Chapter IV: Finance and Trade.
100. The Commonwealth shall not, by any law or regulation of trade or commerce, abridge the right of a State or of the residents therein to the reasonable use of the waters of rivers for conservation or irrigation.
(This is the only reference to water in the Australian Constitution.)

Jim Galletly, PhD,
University of Queensland,
Gatton Campus.

Appendix 1: Freedom in a commons.

Many people are familiar with the scenario outlined by Hardin (1968) in has paper 'The tragedy of the commons'.
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'Picture a pasture open to all. It is to be expected that each herdsman will try to keep as many cattle as possible on the commons. Such an arrangement may have worked reasonably satisfactorily for centuries because tribal wars, poaching and disease kept the numbers of both man and beast below the carrying capacity of the land. Finally, however, comes the day of reckoning, that is, the day when the long-desired goal of social stability becomes a reality. At this point, the inherent logic of the commons remorselessly generates tragedy'.

As a rational being, each herdsman seeks to maximise his gain, and concludes that the only sensible course for him to pursue is to add another animal to his herd. And another. But this is the conclusion reached by each and every rational herdsman sharing the commons. Therein is the tragedy. Each man is locked into a system that compels him to increase his herd without limit – in a world that is limited. Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons. Freedom in a commons brings ruin to all.

Hardin considered that this is one of a class of human problems which can be called "no technical solution problem": i.e. it is a problem which cannot be solved only by technical means: it has social and political aspects which must be tackled concurrently. In the present context, we can substitute groundwater for a pasture, but the result is the same. Freedom in using groundwater as a commons brings ruin to all as has been (and is being) demonstrated in the Lockyer Valley and in the Murray Darling Basin and in many other aquifers throughout the world.

The solution proposed by Hardin is 'mutual coercion, mutually agreed upon'. We must insist that groundwater is not a commons. The aquifers must be managed using mutual coercion, mutually agreed upon by the majority of people affected by the current lack of management. An alternative to the commons need not be perfectly just to be preferable. Injustice is preferable to total ruin. A model of 'mutual coercion, mutually agreed upon' has been operating in Israel in its irrigation system for at least 50 years (Aloni 1970) involving measuring all water use, equitable distribution of water, and levying a fee for all water use; a fee which escalates (as $/ML) for increased use. This could be used as a model for water management in the sub-catchments in the Murray Darling Basin.

In the past, the approach has been for society to appeal to an individual exploiting a commons to restrain himself for the general good, by means of his conscience. To make such an appeal is to set up a selective system that works towards the elimination of conscience from the race. When society makes this appeal, the individual hears not one, but two contradictory messages:
(1) (the intended communication) 'If you don't do as we ask, we will openly condemn you for not acting as a responsible citizen', and
(2) (the unintended communication) 'If you do behave as we ask, we will secretly condemn you for a simpleton who can be shamed into standing aside while the rest of us exploit the commons.'

Every man is then caught in a 'double bind' or 'catch 22' situation which always endangers the mental health of anyone to whom it is applied. 'A bad conscience is a kind of illness.' It is said that 'No good ever came from feeling guilty, neither intelligence, policy, nor compassion. The guilty do not pay attention to the object but only to themselves, and not even to their own interests, which might make sense, but to their anxieties'. We should never use a technique the tendency (if not the intention) of which is psychologically pathogenic. When we use the word 'responsibility' in the absence of substantial sanctions, we are trying to browbeat a free man in a commons into acting against his own interest. Responsibility is the product of definite social arrangements – not propaganda. We need a new system, so the present system needs reform. Reforms will always be opposed by some people, especially those who find a flaw in it. But even an imperfect solution is preferable to ruin. The automatic rejection of proposed reforms is based on one of two unconscious assumptions: (1) that the status quo is perfect, or (2) that the choice we face is between reform and no action. But we can never do nothing because 'for evil to happen, it is enough that good men do nothing'.

Once we are aware that the status quo is action, we can then compare its discoverable advantages and disadvantages and the predicted advantages and disadvantages of the proposed reform. We have already abandoned the commons in a number of areas of human endeavour: food gathering, farm land, sewage disposal, and we are still struggling to close the commons to pollution (by automobiles, factories, atomic energy installations, etc). Every new enclosure of the commons involves an infringement of somebody's personal liberty. There are cries of 'rights' and 'freedom'. But what does 'freedom mean? 'Freedom is the recognition of necessity'. Individuals locked into the logic of the commons are free only to bring on universal ruin; once they see the necessity of mutual coercion, they become free to pursue other goals. With water, there are no other options, because, 'once the water runs out, nothing else matters'.

It is time we looked again at Hardin's philosophy and used it to recognize the necessity of developing 'mutual sanctions, mutually agreed upon' for the purpose of managing water allocations in Australia.

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Extract from Aloni, S (1970) 'Introduction to the Water Laws' in Aloni, S (ed.) *The Water Laws of Israel*, Ministry of Agriculture – Water Commission, State of Israel.

Public participation and right of appeal

Because water is a vitally indispensable commodity, the use of which is widespread in all walks of life, the legislator found it necessary to oblige the administration handling water matters and responsible for the implementation of the law, to involve the public in its activities as much as possible. This finds expression both in the formation of public frameworks which advise those implementing the law, at the head of which is the Water Board, and by giving the widest opportunities to the public, insofar as it considers itself aggrieved by the decisions of the administration to present its criticisms and to object to actions of the Board before committees whose members are elected from the public.

Although there is a certain clumsiness in the administration's work, it is calculated to create maximum safeguards, as the decisions are subject to public examination. The masterpiece of that approach finds expression in the Law by the formation of a special Water Tribunal which serves as a Court for appeals brought by the public against the decisions of the Minister of Agriculture or the Water Commissioner. The Tribunal has the authority of a District Court and a Judge of the District Court serves as its President, with two public representatives at his side.

There is a right of appeal against the decisions of this Tribunal to the High Court. It should be noted that the system detailed above of participation of the Public in the work of the Administration reduces considerably the need for application to the above Tribunal.

Sanctions

As is customary in all other laws, the Water law also contains a punitive clause which sets out the actions which constitute criminal contravention. But in addition to this routine provision, there is also a stipulation which is not routine, enabling the Water Commissioner to impose an Administrative Fine, called a 'Special Payment', in those cases in which there has been a deviation from the water allocations permitted by the Law.

Taking this kind of action is an alternative to bringing a criminal case, and there is no doubt it is more effective. Imposition of a fine on each cubic metre of water extracted or supplied beyond the allocation is calculated to make such deviation unremunerative from the economic point of view, and indirectly to bring about a saving of water.

Water Metering

As stated above, a law for metering of water was enacted in 1956, in recognition of the importance of installing water meters as a means of preventing wastage of water. Today, more than ten years after the implementation of the Law, it may be noted that the system of metering by means of water meters is conducted throughout the country and for all uses of water, whether domestic consumption (including metering for each flat) or for agriculture or industry. It is difficult to describe how the problems of fixing quantities of water and the price thereof would have been solved, were the system not conducted as it is.