Public Health and Safety in relation to Water Purification for Drinking Water Supplies

Advice to the Chief Minister of the ACT and the ACT Government on the health and public safety of the Water2WATER proposal

Prepared by the Expert Panel on Health

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6 July 2007

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Executive Summary

This report has been prepared as the advice to the Chief Minister of the Australian Capital Territory (ACT) and the ACT Government on the public health and safety aspects of ACTEW's *Water2WATER* proposal. This proposal is for the installation of a modern day membrane-based (micro or ultrafiltration followed by reverse osmosis) water purification plant (WPP), followed by wetlands and an enlarged Cotter Reservoir, to access water from the Lower Molonglo Water Quality Control Centre (LMWQCC) effluent for the supplementation of the drinking water supply for Canberra and area.

The Terms of Reference for the Expert Panel on Health (the Panel) focus on the capability of the proposed treatment system to produce a purified water that complies with the quality specified in the 2004 *Australian Drinking Water Guidelines* (ADWG). This has been extended by the Panel to include the new draft 2007 *Australian Guidelines for Water Recycling - augmentation of drinking water supplies* (AGWR) which set out a more rigorous and extensive set of guidelines for this purpose.

While the Panel has examined the information, provided by ACTEW on the *Water2WATER* proposal, it has also considered the context in which this proposal is made. The effect of the current drought and likely impact of climate change on rainfall make the enhancement of Canberra's water resources a necessity. The provision of a secure water supply in an urban area is a first priority for public health, for sanitation and for drinking water supply. The *Water2WATER* proposal provides one alternative mechanism for ensuring water security, based on the reliability of supply of water from the LMWQCC.

A prerequisite for the Panel's work is that public health and safety must not be compromised at all by the *Water2WATER* proposal.

The Panel has reviewed the levels of treatment expected from the proposed WPP and the likely quality of purified water produced. It has assessed the level of risk and has suggested requirements for ACTEW to monitor and manage any residual risk.

The community consultation program has been examined and evaluated, and the community response assessed.

The process and criteria by which the Panel evaluated health risk and its management in safe drinking water supply is explained. Risk is inherent in life, and drinking water guidelines are determined on the basis of acceptable or tolerable risk.

The current Canberra water supply is described, including the raw water quality obtained from the Cotter River, Queanbeyan River and Murrumbidgee River. Only the Murrumbidgee water is supplied directly into the Canberra supply after treatment at Mt. Stromlo Water Treatment Plant (WTP). This plant was constructed in 2004, following the reduction in water quality from the Cotter River after the bushfires. It has capability for handling turbid water from the Cotter or the Murrumbidgee through flocculation and dissolved air flotation, dual medium filtration, chlorine disinfection and is currently being fitted with UV disinfection to further reduce the risk of *Cryptosporidium* entering the drinking water supply.

The Mt. Stromlo WTP forms the last safety barrier of the *Water2WATER* proposal, as it treats the water from the present Cotter Reservoir, and from any future enlarged Cotter Reservoir. It provides drinking water for the whole of Canberra if needed and its operation is carried out in terms of an all-encompassing, third party certified, Hazard

Analysis and Critical Control Point (HACCP) Plan that covers the drinking water supply system in Canberra.

The LMWQCC handles 90% of Canberra's wastewater, which is processed, disinfected and discharged into the Molonglo River upstream of the junction with the Murrumbidgee. The plant is a highly effective operation, removing solid and suspended material, pathogens, degradable organic compounds, phosphorus and a large proportion of nitrogen. The discharge water easily meets all guidelines imposed by the EPA. The present monitoring of the wastewater discharged is described in detail in this report, which includes frequent measurement of major components including faecal organisms, and less frequent measurement of such possible contaminants as pesticides and organic chemicals.

Prior to detailed design of a WPP using this source water from LMWQCC, it is essential to considerably extend the monitoring program to include endocrine disrupting compounds (EDCs), pharmaceutical products and more disinfection by-products. It is also necessary to monitor for a range of possible pathogens, including helminths, protozoa, bacteria and viruses. The LMWQCC is the first barrier in the *Water2WATER* system, which removes the bulk of wastewater contaminants and infectious organisms, and as such it must be protected through a diligent and comprehensive trade waste or source control plan. This latter plan must address all trade waste generated in Canberra and which are discharged to sewer and hence gain access to the LMWQCC. HACCP accreditation for both Trade Waste control and the LMWQCC are required and this must also be incorporated into the current drinking water proposal to ensure that an integrated HACCP plan is in place for the entire *Water2WATER* project.

The initial *Water2WATER* proposal presented to the Panel comprised three alternative treatment trains. One is the reverse osmosis-based (RO) train, and the other two trains rely on ozone/biological activated carbon (BAC). There are fundamental differences between these two approaches in relation to salt, nutrient and organic carbon removal.

In a RO treatment train the salt is separated into a brine stream, distinct from the purified water stream. Only the purified water proceeds into the wetlands and reservoir, therefore not affecting the salt content of the reservoir or the drinking water. However, in the ozone/BAC treatment train, while the pathogens and organic constituents of the water are removed, salts pass unaltered into the output stream. This would increase the salinity of the reservoir water and therefore the drinking water to an unacceptable level.

Further, the two ozone/BAC treatment trains do not achieve the levels of removal of nutrients and organic carbon that are achieved in the RO treatment train, and the Panel therefore recommends that these two treatment trains are not considered further in this proposal.

The proposed treatment train, incorporating reverse osmosis, employs, as first step, microfiltration/ultrafiltration for removal of fine particles, protozoa, bacteria and some viruses. This is followed by RO for removal of salts, larger organic molecules and viruses, then ultraviolet light plus hydrogen peroxide (referred to as the Advanced Oxidation Process) for oxidative destruction of residual viruses and organic chemicals. Operation elsewhere has demonstrated that the reduction in pathogens and chemical contaminants of all types in this RO-based treatment system well exceeds the requirements for drinking water augmentation. The Panel understands that the operational characteristics of this system will be evaluated in a pilot plant in Canberra, prior to final approval of the *Water2Water* proposal.

The purified water produced by the WPP will be pumped up to the Cotter catchment, and discharged into shallow wetlands. The Panel consider that the main benefit from this will be temperature equalization with the environment, reducing hydraulic streaming in the Cotter Reservoir. Some reduction in any residual nutrients and pathogens may also result, depending on the overall biological and temperature environment of the wetland. The Panel also noted that pathogens may also be introduced from the fauna of the wetland, as occurs widely in nature.

Following the wetland the proposal is for the purified water to flow into the Cotter Reservoir. The Panel consider that it is an essential part of the overall proposal to enlarge the Cotter Reservoir, to provide an effective barrier in the supply system. This adds a safety component that cannot be provided by the current reservoir. Without the enlargement the retention time in the small Cotter Reservoir would be short, and the operating limitations on the current reservoir would result in the purified water running over the spillway during periods of rain.

The Panel notes that the purified water entering the Cotter Reservoir will still contain residual levels of nitrate and phosphate and as a result there could be an increase in the concentration of these two nutrients in the water in the Cotter Reservoir. It recommends that this potential increase should be modelled and if there is a likelihood of the increase causing toxic cyanobacterial blooms in the reservoir, then remedial action will be necessary. This remedial action can be modification of the LMWQCC to further reduce nitrogen and phosphate in the feedwater to the WPP and/or the modification of the Mt Stromlo WTP to use powdered activated carbon in the water treatment process in instances when cyanobacterial outbreaks are experienced in the Reservoir.

Risk management of drinking water supply systems using purified water from wastewater sources is a key component of ensuring public health and safety. Such processes inherently carry higher levels of risk, due to the prevalence of pathogens and complex chemicals in untreated wastewater. Acute health effects would be readily observed as outbreaks of disease. Any chronic health effects would be more difficult to measure as they would not be immediately detectable, requiring epidemiological analysis between otherwise comparable populations or comparison over sufficiently long time spans.

Epidemiological investigations to date of populations consuming drinking water augmented with purified water have not shown any increase in gastrointestinal disease. An on-going study of water-borne infectious disease in Canberra would be a valuable monitoring component of the consequences of drinking water augmentation with purified recycled water.

While microbial pathogens are a major concern, the monitoring of pharmaceuticals and their products and natural and synthetic endocrine disruptors in purified water is also essential. Health outcome monitoring is also required, including on-going assessment of community rates of cancer and birth defects from existing population-based data sets.

The Panel notes that with the treatment train proposed by ACTEW and with appropriate levels of operational monitoring and management, along with operator training and skills at the level recommended by the Panel, the quality of purified water that is transferred to the Cotter Reservoir will comply with all the health related guidelines of both the 2004 ADWG and the draft 2007 AGWR.

In addition, the Panel notes that the 2007 draft AGWR states that a treatment train with a configuration as proposed by ACTEW will produce a purified water that complies with the health related guideline values – for both acute and chronic parameters.

Community views on the *Water2WATER* proposal were assessed during the ACTEW consultation process and the consultants will provide a detailed report to ACTEW. The largest single route of community access to information was the ACTEW website, with 4429 hits. Community forums, briefings and displays recorded 2441 contacts.

The Panel received only two formal written submissions, from Engineers Australia and from Professor Peter Collignon. Engineers Australia argued for the expeditious securing of improved water resources for Canberra, with cost-benefit analysis of alternatives. They suggest that a risk management plan for *Water2WATER* should be made available prior to the project being agreed. The detailed submission is available on the website www.expertpanelonhealth.canberra.net.au

The submission from Professor Collignon raised concerns that 'recycling water from sewage into drinking water is a high risk procedure' and that it should only be undertaken as a last resort. He raised concern about adding recycled water into the small Cotter Reservoir, which would mean that the proposal is effectively a direct potable recycling scheme. His full submission is available as above.

The Panel also received e-mails expressing concerns over the *Water2WATER* proposal ranging from outright opposition to concerns about human error and equipment failures.

Overall only a small proportion of the Canberra community actively participated in the community consultation process despite a wide range of mechanisms to do so. Community views that were obtained by random contact and by surveys tended to be positive or neutral to *Water2WATER*, compared to the negative viewpoints of those who submitted their views through e-mail, letters or submissions.

On the basis of all the available information it appears reasonable to conclude that the majority of the community are not greatly concerned with the *Water2WATER* proposal.

Meanwhile, the community has also clearly communicated a desire for a more detailed investigation of other options for securing Canberra's water supply.

The Panel recommends that an on-going community engagement process take place if the *Water2WATER* proposal is adopted. This will allow for more detailed information to be made available to the public, and a long-term collaborative engagement and participation of the public in the development of the proposal.

Overall, at present there is qualified support within the community for the use of non-potable and potable recycled water. However, some concerns have been raised about health and safety issues of the current ACTEW *Water2WATER* proposal. These require sufficient time and resources to be fully addressed. The community recognises the need for the ACT Government to act expeditiously in securing the future water supply, but urges fuller investigation of all options for securing sustainable water for the future.

The Panel considers that a reverse osmosis-based water purification plant is feasible as a method of increasing the water supply for Canberra, subject to stringent health and safety requirements being met as set out in the draft AGWR and the approval of ACT Health as the regulatory body responsible.

The Panel recommends that:

1. ACTEW only proceed to continue investigation into a dual membrane Water Purification Plant (WPP) and that the alternative treatment train using ozone and biologically activated carbon not be considered further, due to the salt, nutrient and organic carbon loads entering the drinking water supply if this method of treatment were to be used;

2. The lower Cotter Reservoir be enlarged and the Panel notes the intention to construct this simultaneously with the water purification plant and ancillaries;

3. An extensive monitoring program be undertaken at the Lower Molonglo Water Quality Control Centre (LMWQCC) on the influent (water entering the system) and effluent (water leaving the system) concentrations of microorganisms and contaminants of concern prior to detailed design of the purification plant;

4. ACTEW provide a Recycled Water Management Plan that includes the following information before the process is commissioned:
   - The staffing levels proposed for the new plant;
   - The level of training that the plant operators will have undergone prior to plant commissioning;
   - The means by which the operation of each of the stages of treatment in the WPP is monitored and maintained at the optimum level (e.g. where relevant, details of membrane integrity testing, specialised on-line instruments etc);
   - An approved Hazard Analysis and Critical Control Point (HACCP) Plan that shows the likely Critical Control Points (CCPs) for the various stages and barriers in the WPP, together with ‘action’ and ‘shutdown’ values; and
   - An integrated Drinking Water HACCP plan that incorporates the Plans for the LMWQCC, the WPP and for the regulation and control of trade wastes that enter the sewer;

5. The WPP be staffed for 24 hours/day for at least the first 5 years of its life;

6. ACTEW carry out a modelling exercise to investigate the impact of the nutrient loading in the purified water on the water quality in the enlarged Cotter Reservoir;

7. An ongoing community engagement process take place if the *Water2WATER* proposal is adopted. This would allow for more detailed information to be made available to the community and to begin developing mechanisms for a longer term collaborative engagement approach in which the community can become partners in decision-making processes; and

8. Community consultation and engagement be incorporated into and inform all stages of future water security initiatives including the planning, design, implementation and management stages of specific projects. This would encourage a system of water stewardship that places a priority on partnerships between the community and water authorities.

List of abbreviations

ACT	Australian Capital Territory
ADWG	Australian Drinking Water Guidelines
AGWR	Australian Guidelines for Water Recycling
ANU	Australian National University
AWWA	Australian Water and Wastewater Association
BAC	Biological activated carbon
BOD	Biochemical Oxygen Demand
CCP	Critical Control Point
CSIRO	Commonwealth Scientific Industry Research Organisation
DALYs	Disability Adjusted Life Years
EDCs	Endocrine disrupting compounds
EPA	Environment Protection Agency
EPHC	Environment Protection and Heritage Council
GL	Gigalitre
GV	Guideline Value
HACCP	Hazard Analysis and Critical Control Point
HRGV	Health Related Guideline Values
IPR	Indirect potable Re-use
IPU	Indirect Potable Use
LMWQCC	Lower Molonglo Water Quality Control Centre
MF	Micro Filtration
NHMRC	National Health and Medical Research Council
NRMMC	Natural Resource Management Ministerial Council
NWC	National Water Commission
PAC	Powdered Activated Carbon
RO	Reverse Osmosis
TN	Total Nitrogen
TP	Total Phosphorous
UF	Ultra Filtration
USA	United States of America
UV	Ultra Violet
VOC	Volatile Organic Compound
WHO	World Health Organisation
WPP	Water Purification Plant
WSAA	Water Services Association of Australia
WTP	Water Treatment Pant
WWTP	Waste Water Treatment Plant

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1. Introduction

a. *Purpose of this paper*

This report provides advice to the Chief Minister of the Australian Capital Territory (ACT) and ACT Government on ACTEW's *Water2WATER* proposal, with respect to risks to public health and safety.

The terms of reference for the independent Expert Panel on Health (the Panel) (see Appendix 1) focus on the provision of advice on the suitability of the proposed water production (purification) facility to supply water into the Cotter Reservoir, for supplementation of the Cotter catchment supply of drinking water for the ACT. The particular focus is on the capability of the proposed treatment systems to remove potential contaminants to the levels specified in the present *Australian Drinking Water Guidelines* (ADWG) (NHMRC, 2004), and the draft *Australian Guidelines for Water Recycling – Augmentation of drinking water supplies* (AGWR) (NRMMC and EPHC, 2007) ensuring that public safety is not compromised.

The Panel has also been asked to consider any residual health risks, including risks arising from potential non-compliance with water purification procedures, and any additional work necessary to complete the assessment and improve the feasibility of the project. The Panel has also been asked to review and report on the outcomes of the community consultation program, and on the community's views of the proposal.

This report presents the current advice of the Panel on the *Water2WATER* proposal, based on the information available to it. While the Panel has accessed current documentation and documentation under confidential draft, both commercial and National, there is much information which can only be obtained through future monitoring, pilot plant operation, and actual testing of the final design. The development of this proposal will necessitate a staged approach. The first stage will require extensive monitoring of the present influent and effluent from the Lower Molonglo Water Quality Control Centre (LMWQCC), and the discharges to sewer from industry and the hospitals. Later stages require assembly and testing of a pilot purification system, again with extensive monitoring. The final stage involves testing and accreditation of the completed system, prior to connection to the water catchment.

While the Panel can point to these future requirements for public safety in the operation of a Water Purification Plant (WPP), this data does not presently exist with respect to the proposed plant, though there is a wide range of data for similar systems elsewhere. There will be an on-going need for evaluation of the health and safety aspects of the *Water2WATER* proposal as the monitoring and technical details are developed and implemented.

b. *Role of the independent Expert Panel on Health*

The first component of the role of the Panel was met by the provision of a public Issues Paper entitled *Health and Public Safety in Water Purification* issued on Friday 25 May 2007. This paper introduced the background to Canberra's present drinking water storage and treatment, and the quality of the water supply. It outlined ACTEW's proposals for alternative water purification systems supplied by discharge water from the LMWQCC, with storage in the present or future Cotter Reservoirs.

A major part of the Issues Paper discussed water safety and security of health for water re-use in drinking water supply, and the extensive technical and monitoring requirements incorporated into such a system. Overseas examples of operating systems were discussed, as were the main epidemiological studies of health outcomes carried out on consumers of the recycled water.

The concerns raised by members of the ACT community were illustrated, together with the ACTEW information and media coverage. The Issues paper concludes with a summary of the health issues raised by the community for consideration by the Panel.

This final report provides the second component of the Panel's role, namely the provision of advice in relation to the safety of the proposed recycling process to supplement the drinking water supply. From the perspective of public health, the proposal must:

- Meet ACT Health and Public Health Act requirements;
- Meet the ADWG standards;
- Meet the draft AGWR standards; and
- Comply with the approach of the World Health Organisation (WHO), the National Health and Medical Research Council (NHMRC) and the Natural Resources Management Ministerial Council (NRMMC) to risk management in drinking water supply.

c. Principles

In principle, there are three categories of risk to health that are relevant to the Panel's deliberations. These are:

1. Water security – ensuring there is and will be enough water for sustainable healthy living;
2. Water quality – the reticulated water supplied to the community is free of risks to health at the level specified by the Australian Guidelines (ADWG and AGWR); and
3. The waste materials extracted by the purification process are disposed in a way that does not cause health risks.

The first priority of any water supply for the urban population must be water security. The greatest risk to health and safety of the population is the failure of the reticulated water supply to provide water. In the urban context, basic sanitation and drinking water access are essential. It is therefore imperative that the security of Canberra's drinking water resources are assured, in the present situation of climate change and drought events. There needs to be adequate water sources to sustain supply, and adequate storage to ensure supply during periods of drought. However it is not the role of this Panel to advise on the best mechanisms to ensure that this basic aspect of water-related health and safety requirements is met. Nevertheless, the Panel is acutely aware of the health risks of failure of the water supply, and affirms that action to ensure future supply is required.

The Panel's work has been focused on the paramount second category of the above three categories. Brief comment and advice is also offered on the third category.

Water purification and recycling is an option that deserves careful consideration for the future of water security here and in other parts of Southern Australia.

The Panel is also acutely aware of the inevitable community concern over the idea of introducing water purified from wastewater, even after additional high-level purification, into the drinking water supply. It has been argued, in relation to this proposal and elsewhere, that to mix treated sewage with the environmental drinking water supply is a retrograde step, one that reverses 150 years of sanitary engineering directed at successfully separating those two compartments. The argument often implies that water produced from wastewater is inherently different to water falling as rain. To counter the argument, the essential requirement of water purification must be that negligible levels of contaminants are present in the water produced, with no detectable effects on the health of consumers.

There are however three criteria that must be met for the successful introduction of water recycling for drinking water supply: first, that there is sufficiently great need, in light of current and growing demand and projected climate trends, to take action to ensure the adequate future supply of potable water; second, that there is no alternative reliable, sustainable and sufficient source of supplementary drinking water; and third, that there is now available reliable and effective technology able to ensure the safety of the ultra-treated recycled water.

Water quality control forms the major part of this report, as it is the key issue for public health in any drinking water supply system, and becomes particularly important in a recycling proposal. Waste disposal and energy efficiency are under investigation by other groups, and will not be considered by this Panel.

d. Methodology of the Panel

To meet the Terms of Reference for the Panel, considerable quantities of information and technical data have been assembled by the Panel. Of greatest relevance are the reports to ACTEW on the technical feasibility and monitoring requirements for water purification, the water quality modelling data for the Cotter Reservoir, and the working group draft of the AGWR (NRMMC and EPHC, 2007). The Panel has also used the present ADWG (NHMRC, 2004) and the WHO *Third Edition Guidelines* (WHO, 2004) which form the basis for legislation on drinking water safety. There have been several recent overviews of use of recycled water for supplementation of the drinking water supply from individual researchers and from organizations, the most recent being the National Water Commission (NWC) *Using Recycled Water for Drinking* in June 2007. This report is recommended as a source of information for public scrutiny and can be found at:
http://www.nwc.gov.au/publications/docs/RecycledWaterForDrinking.pdf.

The Panel has received copies of the reports from the three groups from Canberra that have travelled overseas to visit operating water purification plants in the USA, Europe and Singapore.

Members of the Panel have attended five public meetings to discuss aspects of the *Water2WATER* proposal and answer questions. Numerous e-mail letters have reached the Panel, and consideration of these and of the submissions is incorporated in this report. The Panel has overviewed the ACTEW public consultation process, the media coverage and the results of public opinion surveys.

The Panel has a website for public access www.expertpanelonhealth.canberra.net.au for contact, information and lodging of submissions. Two relevant submissions can be found on the Panel website

In order to advise on health and public safety aspects of ACTEW's *Water2WATER* proposal, the Panel has evaluated the *Water2WATER* water purification proposals on the basis of the risk to health presented to consumers. This risk assessment approach has been developed for a wide range of potentially harmful situations, including drinking water supply (NHMRC, 2004; Environmental Health Risk Assessment, 2002). The first step in risk assessment is to identify and characterize potential hazards to health. In relation to safety of drinking water supplies, these are hazards from potential pathogenic contaminants and from a range of chemical contaminants. The magnitude of the risks then relates to the likelihood of those contaminants occurring in the water supply, and of the impact of their occurrence on the health and safety of the population. Further description of the risk assessment process is found in Section 5 of this report.

e. Context of the advice from the Panel

This advice to the Chief Minister is one component of a series of reports that have been commissioned by the ACT Government to evaluate the *Water2WATER* proposal. It will be considered together with reports on the environmental implications, alternative water supply possibilities, economic considerations and public perceptions. ACTEW reports on the Technical Feasibility of a water purification plant at LMWQCC and a Review of Water Quality and Water Quality Monitoring will also be considered.

2. Current water quality and systems

a. Water Supply

The current drinking water supply for Canberra and Queanbeyan is a network of pipelines, storage tanks and water treatment plants, supplied with water from several sources, as illustrated in Figure 1.

The primary sources of water are the Cotter River catchment, the Queanbeyan River catchment and now the upper Murrumbidgee Catchment. The Cotter catchment is highly protected, particularly above Bendora dam, where it is part of the wilderness area of Namadgi National Park. This supplies exceptionally good quality water. The lower Cotter River area adjacent to the lower Cotter dam was extensively damaged by the bushfires in the pine forest areas, and is need of ongoing conservation and protection to enhance water quality.

The Queanbeyan River supplies water to Googong dam, from a catchment that is extensively affected by population growth, unsewered dwellings and intensification of agriculture. Burra Creek in particular carries a high microbial load. Pesticide use in the catchment could result in detection in raw water. The combination of land-use factors reduces the available water inflow to the river due to extraction of water by bores and farm dams, and reduces quality through animal and human wastes.

The Murrumbidgee River is now in use as a direct water source for Canberra's supply, through pumps in the river below the Cotter River junction. This is an extensive area of catchment, receiving treated wastewater from Cooma, agricultural runoff, unsewered dwellings, and contaminated stormwater runoff from the Tuggeranong district of the ACT. It is the lowest quality of raw water in the Canberra supply system, and the quality varies greatly with rainfall. Heavy rain increases faecal contamination considerably. *Cryptosporidium* has been detected in water sampled at several points of present and potential future abstraction from the river.

b. Water Storage

The total water storage capacity of the Canberra/Queanbeyan drinking water supply is approximately 200 Gigalitres (GL) (two hundred thousand million litres, or two hundred billion litres). This supplies the annual use under normal circumstance of approximately 65 GL and therefore contains about three years supply. Last year only 20GL of inflow was received into storages, and the current storage level is approximately 30% of capacity (60GL or approximately eleven months full supply). The use of direct pumping from the Murrumbidgee will extend the supply availability, but is subject to quality and flow restrictions. Rain in the catchment will further extend the supply and reduce demand, as does the use of water restrictions. Reduction in demand for water can be accomplished by increased efficiency, use of alternative sources, cost of water and water restrictions. Even with reduced demand it is apparent that the combination of reduced inflows and potentially increased variability of rainfall into Canberra's storages and increasing population will necessitate an increase in storage capacity. This increase will be needed regardless of the installation of water purification and recycling.

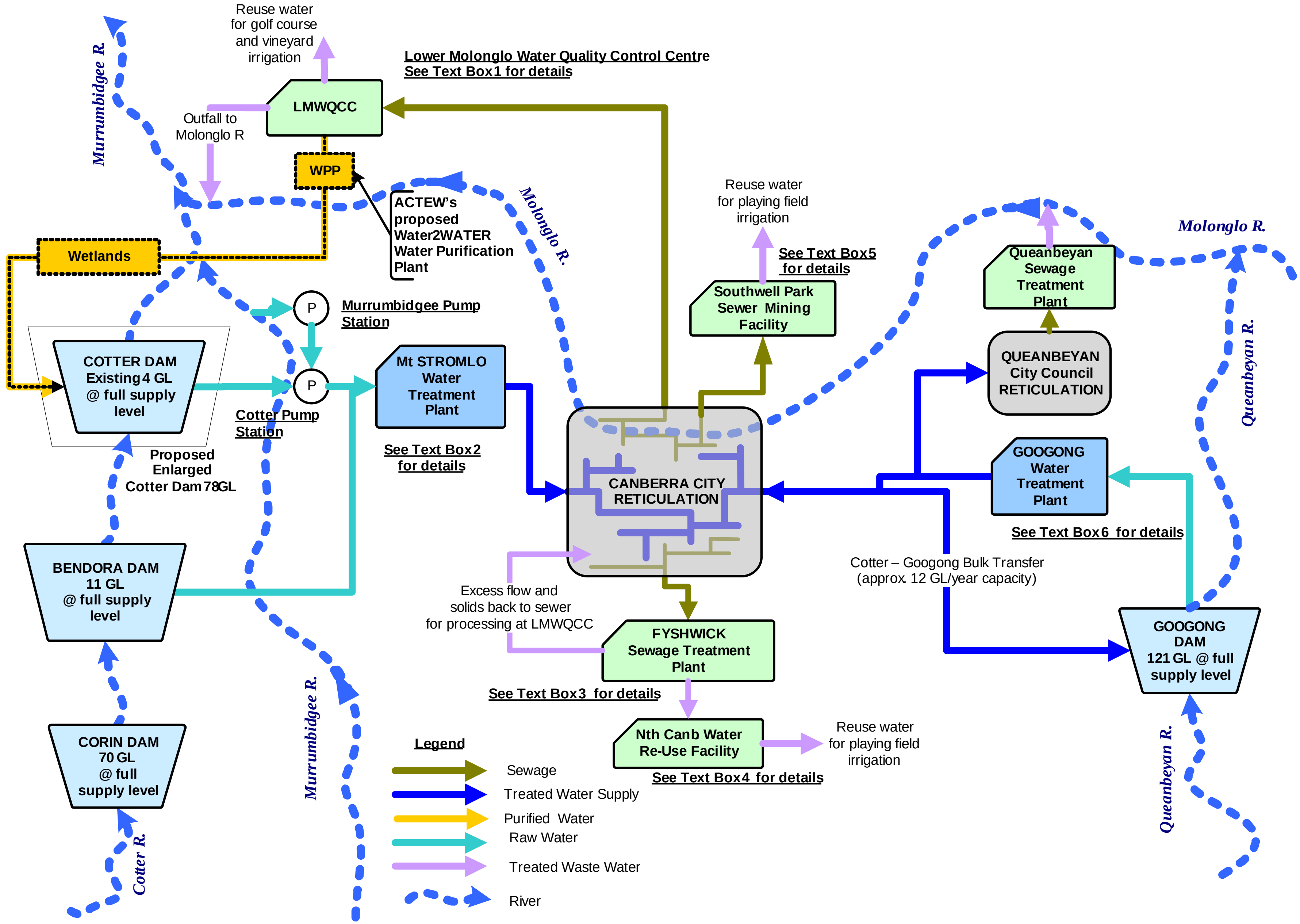

Figure 1: Water and Sewage Treatment Processes in Canberra showing ACTEW's Proposed Water Purification Plant

Box 1: Lower Molonglo Water Quality Control Centre

Capacity - 90 Ml/d – nominal

Key Processes - 7 Steps

1. Screening: Remove large objects, post-screening add chemicals: ferrous chloride & lime, grit removal.

2. Primary sedimentation: Chemical treatment precipitates: heavy metals, organics, phosphates (binds together (flocculation)) by addition of polymer. Settles solids to bottom of tanks, skims fats and soaps from the surface. Sludge and scum removal (refer Step 7).

3. Biological Reactor Tanks: Remove ammonia. Settled effluent mixed with activated sludge containing microorganisms converting ammonia to nitrates under aerobic conditions, and converts nitrates to nitrogen gas under anoxic conditions.

4. Secondary Clarification: Remove microorganisms from secondary treated effluent and recycle microorganisms to biological reactor tanks.

5. Addition of more ferrous chloride to remove phosphorus. Water passes through filters of finely crushed coal and sand.

6. Chlorination/De-Chlorination: Chlorine added to disinfect for microbiological pathogens (45 minute detention) and then treated with sulphur dioxide gas to remove excess chlorine.

7. Solids Separation and Incineration (0.7 Ml/d): Sludge converted to Agri-Ash, scum incinerated.

Catch Dam: Capacity 140 Ml to capture partially treated wastewater from by-passses, spillages and drainage and return to process for treatment.

Box 2: Mt Stromlo Water Treatment Plant

Capacity - 250 Ml/d

Key Processes:

- Direct Filtration
- Dissolved air flotation and filtration
- Coagulation & flocculation
- Optional dissolved air flotation
- Dissolved air flotation & filtration or direct filtration
- Disinfection by chlorination.
- pH adjustment and stabilization with lime and carbon dioxide
- Fluoridation by Sodium Silico Fluoride.
- Ultraviolet Disinfection (under construction)

Box 5: Southwell Park Sewer Mining Facility

Capacity – 0.5 Ml/d

Key Processes:

- Pre-Screening
- Chemical Pre-Dosing
- Biological organic carbon removal & nitrification
- Membrane Filtration
- Chemical Post-Dosing
- Chlorine Disinfection

Box 3: Fyshwick Sewage Treatment Plant

Capacity – 5 Ml/d (nominal)

Key Processes:

(Industrial & Domestic Sewage)

- Primary Sedimentation
- Trickling Filters
- Humus Tanks
- Maturation Lagoons
- Emergency Storage Lagoon

Box 6: Googong Water Treatment Plant

Capacity – 270 Ml/d

Key Processes:

- Clarification & filtration system + Dissolved air flotation and filtration.
- Optional powdered activated carbon for organic matter removal
- coagulation and flocculation
- dissolved air flotation and direct filtration (90 Ml/d)
- Flocculation, clarification and filtration (180 Ml/d)
- chlorination
- pH adjustment
- Fluoridation
- Chlorine disinfection

Box 4: North Canberra Water Re-use Facility

Capacity – 1.78 Ml/d

Key Processes:

- Membrane Filtration
- Chlorine Disinfection

c. Drinking water treatment

Drinking water treatment is provided by the new Mt Stromlo Water Treatment Plant (WTP) (see Box 2), and the 1970s Googong WTP (see Box 6). Both plants are of conventional design, using aluminium sulphate as a flocculant for particle removal, with both mixed media filtration and optional dissolved air flotation for more turbid water treatment when necessary. Disinfection of the treated water is carried out with chlorine and in the case of Mt Stromlo WTP, by chlorine and ultraviolet light, complying with the regulations for drinking water quality. The Googong WTP additionally has capacity to use powdered activated carbon for removal of undesirable organic constituents, such as pesticides, cyanobacterial toxins and tastes and odours. To provide additional safety for use of the Murrumbidgee river water at the Mt Stromlo WTP, an ultraviolet light disinfection unit is being installed for inactivation of *Cryptosporidium* cysts. The water produced from both plants meets the ADWG (NHMRC, 2004). Table 1 provides a summary of the two drinking water treatment plants and the Waste Water Treatment Plant (WWTP) at LMWQCC

Table 1: Summary of Three Main Water Treatment Plants in Canberra

Water Treatment Plant	**Output**	**Source Water**	**Quality of Source Water**	**Treatment Process**
Googong	Drinking water supply	Queanbeyan River catchment	Potential contamination containing pathogens and pesticides: agricultural runoff, septic overflow. Likely to deteriorate with urbanisation	Coagulation, sedimentation, and filtration; Dissolved air flotation; Powdered activated carbon; chlorine disinfection, fluoridation and acidity adjustment
Mt Stromlo	Drinking water supply	Cotter Catchment Murrumbidgee	Post 2003 fires poorer quality. Currently free from human contaminants Potential contamination containing pathogens and pesticides: agricultural runoff, septic overflow and urban stormwater	Coagulation, flocculation, and filtration; Dissolved air flotation; chlorine disinfection, fluoridation and acidity adjustment; UV light disinfection (by end 2007)
Lower Molonglo Water Quality Control Centre	Treated wastewater	Domestic, commercial and industrial wastewater	Raw sewage containing pathogens, hormones, pharmaceuticals etc, other chemicals and a high nutrient load	Physical screening; flocculation, precipitation and sedimentation, activated sludge (biological treatment), nitrification, partial denitrification, chemical phosphorous removal, coal/sand filtering, chlorine disinfection

Source: ACTEW

Monitoring of the reservoirs and the drinking water for chemical contaminants and microbial pathogens follows the ADWG (NHMRC, 2004), which include monitoring for pesticides, metals, cyanobacteria, disinfection by-products and faecal coliforms. There are no guidelines for pharmaceuticals, endocrine disrupting chemicals, protozoal or viral pathogens in the ADWG (NHMRC, 2004). Faecal coliforms, measured as thermo-tolerant coliforms, and, specifically, *Escherichia coli* are accepted indices for monitoring faecal contamination, though they do not directly measure virus or protozoal pathogens. A summary of the parameters measured at Mt Stromlo WTP is in Table 2.

Table 2: Summary of Water Quality from Mt Stromlo Water Treatment Plant

Parameter	Target/ Units	Number of samples	Number meeting target	% meeting target	Mean	Minimum	Maximum
PH	**6.5 to 8.5**	49	49	100.0%	7.7	7.4	8.1
Alkalinity	**<200 mg/L as CaCO3**	13	13	100.0%	40	31	51
Hardness	**<200 mg/L as CaCO3**	3	3	100.0%	45	35	57
Turbidity	**<5 NTU**	49	49	100.0%	0.29	<1	1
Colour	**<15 Pt-Co**	49	49	100.0%	1.1	<1	2
Chlorine	**<5 mg/L**	320	320	100.0%	1.14	0.82	1.40
Fluoride	**<1.2 mg/L**	49	49	100.0%	0.81	<0.05	1.1
THMs	**<250 mg/L**	12	12	100.0%	10.7	4	16
Aluminium	**<0.2 mg/L**	51	51	100.0%	0.050	0.010	0.18
Iron	**<0.3 mg/L**	50	50	100.0%	0.013	0.010	0.06
Manganese	**<0.1 mg/L**	50	50	100.0%	0.005	0.001	0.026
Copper	**<2 mg/L**	1	1	100.0%	<0.001	<0.001	<0.001
Lead	**<0.01 mg/L**	1	1	100.0%	<0.0002	<0.0002	<0.0002
Total coliforms	**0 CFU/100mL in 95% of samples**	343	343	100.0%	0	0	<1
Faecal coliforms	**0 CFU/100mL in 98% of samples**	343	343	100.0%	0	0	<1

Source: ACTEW

The operation and control of both the Googong and Mt Stromlo WTPs are included in the overall third party Drinking Water Hazard Analysis and Critical Control Point (HACCP) Plan that ActewAGL has in place. The principle of HACCP analysis was developed in the 1970s in the US to prevent hazards that cause food-borne illness by applying controls from the raw materials through the entire production system to the finished product. The HACCP analysis culminates in a HACCP Plan that identifies CCPs in the production system, with the CCPs being measured continuously by on-line instruments and which are linked into the overall plant control system. It is essentially a preventative system of control that assures product safety while reducing, but not eliminating, the reliance on end-product testing.

d. Wastewater Treatment.

The key water treatment plant for wastewater in the Canberra/ Queanbeyan water system is the LMWQCC (see Box 1), which processes approximately 90% of the wastewater generated. A summary of the LMWQCC is in Table 1. The remaining wastewater is processed by the Queanbeyan Sewage Treatment Plant, discharging into the Molonglo River upstream of Lake Burley Griffin (this does not enter the Canberra drinking water supply), the Fyshwick Sewage Treatment Plant (see Box 3) which produces water recycled to sports fields north of the Molonglo river, and material to the main sewers, and a small water reclamation unit at Southwell Park

(See Box 5), producing recycled water for adjacent sports fields and discharging concentrated material back to the sewer.

In summer during low-flow periods in the Murrumbidgee River, the major part of the downstream flow in the river from the ACT is treated water produced from the LMWQCC. This water flows into Burrinjuck Dam, and is supplied for urban and agricultural use lower in the river.

The LMWQCC processes about 90ML/day (33GL/year) of wastewater, by a multi-stage system employing screening to remove large objects; ferrous chloride to flocculate particulate matter, metals, phosphates, and a range of organic compounds bound to the sediment; anoxic and aerated biological reactors using activated sludge to reduce nitrogen and organic load; clarification to remove organisms; further ferrous chloride to lower phosphorus in solution and final filtration to remove fine particles. The resulting water is chlorinated to disinfect any residual pathogens, de-chlorinated to remove excess chlorine that would damage fish in the river, and then passes via a series of cascades into the Molonglo River just upstream of the Murrumbidgee junction. A small proportion of this water is pumped up to irrigate a golf course and the vineyards close to the treatment plant.

The treated water meets the health requirements for recycled water for irrigation. These requirements include monitoring for pathogens represented by thermotolerant coliforms, nitrogen, phosphorus, total dissolved solids (mostly salt) and biological oxygen demand. Limits to these constituents were set by the Environment Protection Authority when licensing the plant for operation. Details of actual quantities discharged and the current license limits are shown in Table 3.

Table 3: Summary of LMWQCC Water Quality Performance

	EPA Authorisation Summary	**Typical Water Quality Performance**
PUBLIC HEALTH		
Thermotolerant coliforms	Median < 60cfu/100ml (80% < 200cfu/100ml)	3 cfu/100ml (80% < 6cfu/ml)
Chlorine residual	< 02. mg/L	<0.075 mg/L
pH	6.5 to 8.5	7.5 to 8.0
ENVIRONMENTAL		
Biochemical Oxygen Demand (BOD)	Median 4.0 mg/L (90%<8.0 mg/L)	< 2.0 mg/L
Suspended Solids	Median 5.0 mg/L (90% < 10 mg/L)	< 2.0 mg/L
Turbidity	Not specified	Generally < 2 NTU
Total Dissolved Solids	Median 500 mg/L (90% < 550 mg/L)	<480 mg/L (90% < 0.06 mg/L)
Specific Conductance	Not specified	Median <740 uS/cm
Ammonia	Seasonal in range 1.6 to 7.4 mg/L	< 0.04 mg/L (90% < 0.06 mg/L)
Total Nitrogen	2,100 kg/day (12 month average)	< 1,900 kg/day
Total Phosphorous	Median Concentration 0.3 mg/L (90% < 0.4 mg/L) Average load 25 kg/day	<0.2 mg/L (90% < 0.3 mg/L) < 16 kg/day

Source: ACTEW

In addition, there is also another suite of analytes (both inorganic and organic) that are periodically monitored for, as part of the Environment Protection Authority (EPA) Licence, albeit at a reduced frequency to that stipulated for those listed in Table 3 above.

In the event of the *Water2WATER* proposal being progressed, it will be necessary for the monitoring and license requirements to be greatly expanded, with a far greater number of pathogens and chemicals of concern monitored and more rigorous limits imposed. It is therefore assumed unequivocally by the Panel that the regulations for water reuse for potable supply will include a range of chemicals of concern including endocrine disrupting chemicals, pesticides, pharmaceuticals and their by-products, chlorination by-products, and regulation of protozoal pathogens such as Cryptosporidium, representative faecal bacteria and representatives of enteric viruses, much as is outlined in the AGWR (NRMMC and EPHC, 2007) and is in place elsewhere in the world. It is recommended that an extended monitoring program is put in place as soon as possible, to provide key data for the design of the purification plant.

At present the LMWQCC is not operated to a third party certified HACCP Plan but the Panel understands that steps are underway to achieve this certification in the near future.

3. *Water2WATER* proposal

A schematic of the *Water2WATER* proposal is shown in Figure 2. It will be noted that the proposal entails the construction of a WPP at the LMWQCC. This new WPP will treat the water from LMWQCC that is currently released to the Molonglo River, to produce high quality water that is then transported to the Cotter Reservoir, via a series of created wetlands. The Cotter Reservoir will be enlarged and the resulting blend of water from this reservoir will then be transported to the Mt Stromlo WTP for further treatment to produce drinking water that is then reticulated into Canberra City.

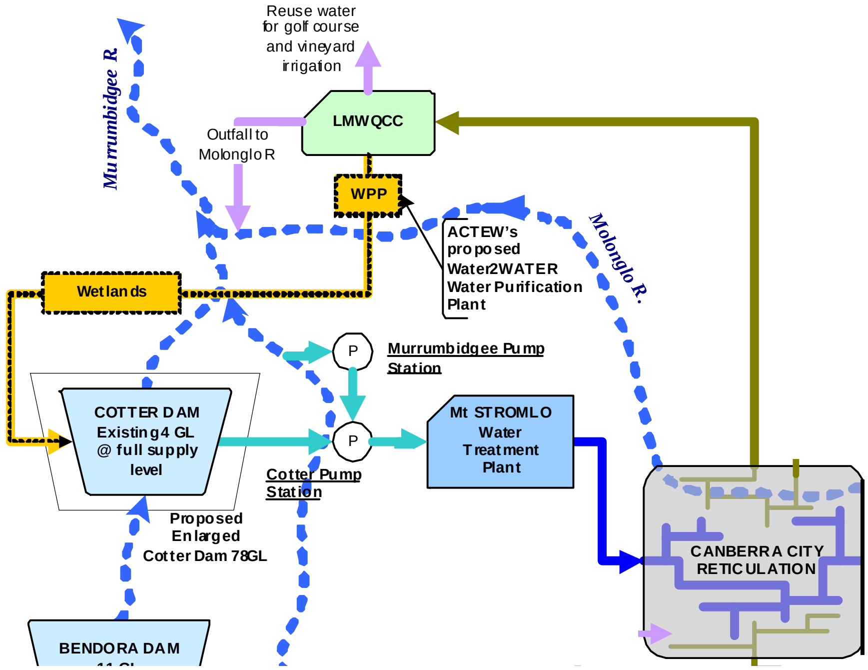

Figure 2: A schematic of the Water2WATER proposal

This Section of the Panel Report addresses four key items in the proposal: the Lower Molonglo WQCC; the proposed Water Purification Plant; the enlarged Cotter Reservoir; and the Mt Stromlo WTP.

a. LMWQCC

The LMWQCC has been briefly described in Section 2d and further discussion on the quality of the water that is currently produced from this facility is presented in Section 4b.

The Panel notes that a project currently underway at the plant will, once commissioned, ensure that the nitrate concentration in the water currently discharged to the Molonglo River will be reduced from some 22-23 mg/L to below 10 mg/L over a period of years.

The Panel also notes that ACTEW has identified that there may be a necessity to further reduce the nitrate concentration in the discharge water from LMWQCC to ensure that the nitrogen level in the purified water does not cause eutrophication once it is added to the reservoir as part of the *Water2WATER* project.

This increased level of nitrate removal at the LMWQCC is still to be addressed and is dependent upon the removal of nitrate achieved through the WPP as well as the impact of the remaining nitrate in the purified water on the reservoir water quality. It may well be that no further nitrate reduction is required at LMWQCC.

b. Water Purification Plant

ACTEW has stated that the quality of the purified water produced at the proposed WPP will meet four specific objectives, namely it will:

- Meet ACT Health & Public Health Act requirements;
- Meet all ADWG (NHMRC, 2004) requirements;
- Meet requirements of the draft AGWR (NRMMC and EPHC, 2007); and
- Be compatible with international practice (as appropriate).

ACTEW were considering three treatment process trains for the WPP, one of which was based on the use of membranes (micro-or ultra-filtration followed by reverse osmosis) to produce the required quality of purified water, while the other two were based on the use of ozone and activated carbon, without the reverse osmosis stage.

The Panel understands that ACTEW have recently decided to proceed only with the dual membrane option for the following main reasons:

- the lack of salt (or Total Dissolved Salt) removal through the Ozone/Activated carbon options that has been shown to affect significant increases in the salinity of the water in the Cotter Reservoir and thus, in the drinking water distributed to Canberra City; and
- the lack of nutrient removal – particularly nitrogen – through the Ozone/Activated Carbon options that would result in very high nutrient loads being imposed in the Cotter Reservoir and increase the risk of severe cyanobacterial outbreaks occurring.

The Panel supports this decision and it notes that there is an added significant disadvantage of the two ozone/activated carbon options in that the dissolved organic carbon is only reduced by some 50% - based on the experience at the South Caboolture plant in Queensland. This is contrast to the 97-99% removal achieved in the membrane plants employing reverse osmosis.

The Panel views organic carbon reduction as being very important as this parameter serves as a surrogate for overall organic compound removal through a WPP.

The Panel also notes that by removing salt at the proposed WPP (by means of reverse osmosis), there will not be any increase in salinity in the drinking water distributed from the MT Stromlo WTP as the purified water will have a salinity the same as that currently in the Cotter Reservoir.

A flow schematic of the proposed treatment train for the WPP is shown in Figure 3.

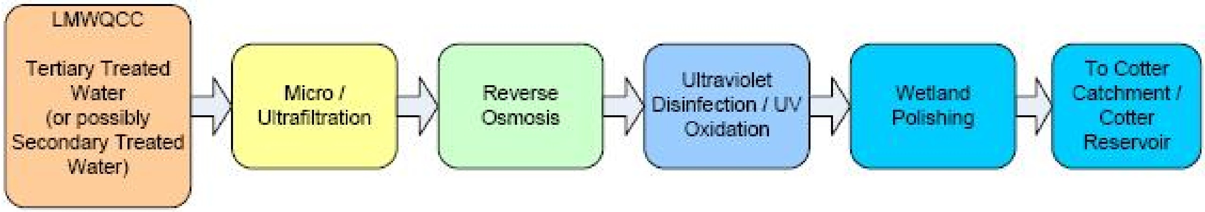

Figure 3: Flow Schematic of the Proposed Water Purification Plant.

The plant will source water from either the outlet of the tertiary filters or from the secondary treatment stage of LMWQCC (exact location will depend on need for management of the nitrate concentration in the final treated water for release to the Cotter Reservoir).

This process train is very similar to that used at the four NEWater plants in Singapore, at the Orange County Water District Ground Water Replenishment System (formerly Water Factory 21) in California, at the Scottsdale Water Campus in Arizona, at the West Basin Water Recycling Project in California and the four plants currently under construction in South East Queensland as part of the Western Corridor Recycling Project.

It is also recognised in the draft AGWR (NRMMC and EPHC 2007) as a process train that can produce a water of a quality suitable for being used to augment drinking water supplies.

The Panel notes therefore that the treatment train selected by ACTEW for the WPP is one that has found acceptance around the world and in Australia. This worldwide acceptance of dual membrane plants is due to the efficacy of such plants in removing a wide range of contaminants, as is shown in Figure 4.

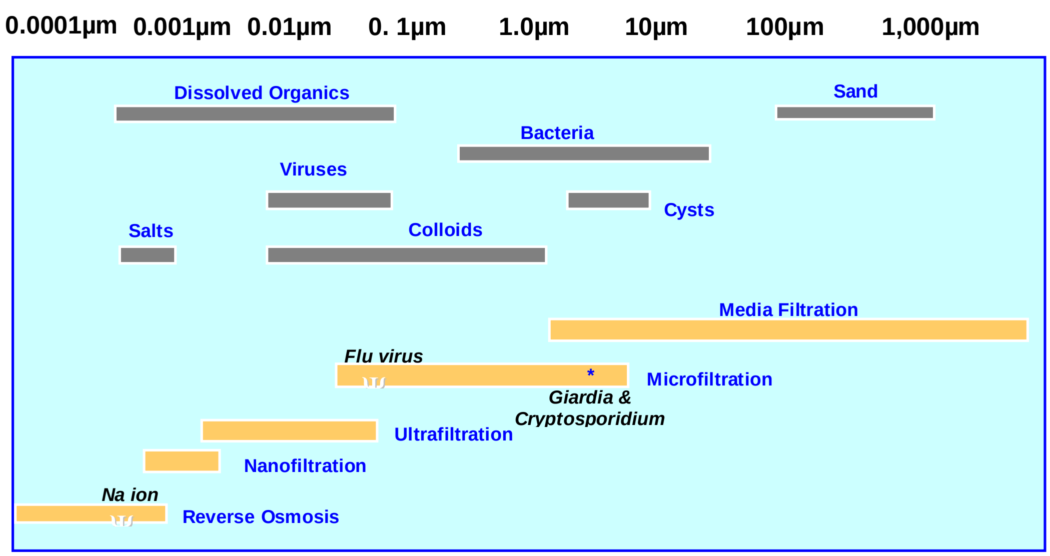

Figure 4: Membrane Process Application Guide

It will be noted that by coupling microfiltration (MF) or ultrafiltration (UF) with reverse osmosis (RO) in the WPP, after a media filtration stage (e.g. the filters at the LMWQCC), very high removals of the contaminants will occur.

The Panel has also considered the fate of the side-streams produced by the proposed process, the most significant of which is the brine or reject flow from the reverse osmosis (RO) stage that will contain the salt and other contaminants rejected by the RO system. It has reviewed the salt modelling work that ACTEW has carried out to establish possible solutions.

The Panel understands that the brine flow from Stage 1 of the WPP (product flow of 25 ML/d) will be routed back to the discharge from the LMWQCC to the Molonglo River, noting that the mass load of salt discharged at this point will not increase; in fact there will be a slight decrease from the present situation.

The Panel understands that ACTEW will be conducting pilot plant studies to verify the performance of the proposed treatment train. It notes that a sampling and monitoring programme has been drawn up for these studies (Ecowise, 2007) and recommends that the outcome of these studies be independently audited for compliance with the four objectives put forward by ACTEW (as summarised above) *before* the full-scale project proceeds. Further discussion on monitoring is presented in Section 6 below.

c. Enlarged Cotter Reservoir

The present lower Cotter Reservoir was constructed in 1912 to provide the small population of Canberra with adequate water storage for the supply requirement of that time. It was extended by raising the dam wall in 1951 but was taken out of service when Corin (1968) and Bendora (1961) dams were built, with these dams providing a higher quality of water under gravity flow to the city, needing only chlorination to meet the health requirements.

The Cotter dam was reactivated in 2004 to supplement the other water resources of the city. However as a result of the bushfires the reservoir water from the whole catchment became unusable without treatment, and the new (2004) Stromlo water treatment plant was built in 2004 to allow the continuation of this supply.

The reservoir holds just under 4GL of water, and is restricted in operation in order to conserve the environment of two endangered fish species, the two-spined blackfish and the Macquarie perch. These species were protected from invasive fish such as carp and trout, and fish diseases, by the original dam construction, which isolated them from the Murrumbidgee River.

The Reservoir is currently mixed to a depth of 12m and there are plans to increase the mixing to greater depths.

The Panel understands that ACTEW has plans to extend the Cotter Reservoir to some 80 GL in volume and that this work will proceed at the same time as the work for the water purification plant, the transfer pipeline and the wetlands.

The Panel supports the enlargement of the lower Cotter Reservoir and the intention to construct this simultaneously with the water purification pant and ancillaries. It notes that this enlargement will certainly minimise the occurrence of temperature induced short-circuiting of the purified water

It has also noted that with the substantial catchment area feeding directly into the Cotter dam, there will be less spilling of the reservoir in the event of the inflow to the reservoir being supplemented by a substantial flow of purified water.

d. Mt Stromlo WTP

The new Mt Stromlo WTP, in operation since October 2004, incorporates a number of barriers that equip it to readily handle a wide range of raw water qualities, as outlined in Table 1 in Section 2a. The Panel notes that ultraviolet (UV) light disinfection will be installed and operational at the Mt Stromlo WTP by the end of September 2007. This additional treatment process will incorporate high intensity UV light that will add a further disinfection stage to the treatment train and one that will, in conjunction with the existing chlorine disinfection stage, achieve significant destruction of a wide range of microorganisms and in particular virus and protozoan pathogens.

4. Water safety and security of *Water2WATER*

While purified water is a valuable resource, great care must be taken to ensure that the protection of public health is never compromised when it is introduced.

The Panel notes that the level of stringency applied to indirect potable reuse projects, both in technology and operations, is well beyond that which is common international practice and which occurs in conventional water treatment and supply in Australia.

The safety and security of the water produced by the proposed water purification plant that is to be constructed at LMWQCC has been the major focus of the Panel. As a result it has looked for details of how 'safety and security' are to be assured in the overall *Water2WATER* proposal.

Items that the Panel has considered in this Section of the Report include:

- the presence and nature of trade waste in the feedwater to LMWQCC and how these wastes are regulated;
- the quality of the water released from LMWQCC into the Molonglo River;
- the capacity of the proposed water purification plant to remove contaminants from the water from LMWQCC;
- the quality of the purified recycled water;
- the safety of the transport to, and storage in, Cotter Reservoir; and
- the quality of water produced from the Mt Stromlo WTP.

In addition, the Panel has considered the on-going monitoring requirements that will have to be in place before the system is commissioned and discussion on this is presented in Sections 5e and 6.

The Panel has also considered the operator skills that will be required to operate the water purification plant as well as the means by which operational reliability is assured and these are further discussed in Section 5d.

a. Trade Waste Regulation and Management in the ACT

A clear understanding of the nature and magnitude of trade waste discharges to the sewers is an absolute pre-requisite for any indirect potable reuse scheme and it is not uncommon for regulations to be revised to ensure that such wastes do not impact on the quality of water to be purified. In some cases, eg Singapore and Windhoek, Namibia, industries have been located in catchments that do not drain to the WTP from which the feedwater to the water purification plant is drawn.

Discharge of trade waste into the Canberra sewer system is controlled by regulations and permits to discharge. Canberra has no major toxic waste-generating industry, however there are several smaller commercial operators in the ACT who are licensed for waste discharge. Canberra's hospitals, universities and private laboratories also have licences to discharge trade waste into the sewer system. Hospital and research discharges to sewers are relevant to wastewater quality, particularly with respect to pathogens and to radionuclides.

The Panel understands from ACT Health that there are protocols in place to control the ingress of hospital wastes into the sewers covering the following categories:

- Cytotoxic Drugs;
- Radioactive Materials;
- Infusion & Non-infusion Drugs;
- Food Substances;
- Flammables & Corrosives; and
- Disinfectants & Sanitisers.

In addition, it understands that all clinical wastes (predominantly blood) are not discharged to sewer at all but are handled separately and after autoclaving are disposed of to landfill.

The Panel notes that ACTEW plans to undertake a detailed hazard and risk assessment of all trade waste discharges and how they might impact on the ability of the water purification plant to produce the quality of water required for the purification scheme using the principles of HACCP. This review will focus on commercial and industrial liquid waste discharges and the operation and maintenance of sewage treatment facilities.

The Panel has reviewed a document (Water Futures, 2007) that was submitted as part of this contract and notes that the objectives of this project are:

- An assessment of the risks from inputs to the Canberra sewer network when purified water is recycled via the LMWQCC to the Cotter Reservoir; and
- Identification of practicable controls required to reduce those risks to tolerable levels.

The Panel notes from the document submitted for review that "*there appear to be no atypical industries in Canberra, compared to other jurisdictions currently undertaking recycling projects and in particular,* [indirect potable use] *IPU (or considering IPU) within Australia, which may be unmanageable within Canberra's IPU context*".

The panel also notes that once completed, the trade waste input management and surveillance processes will be integrated into ActewAGL's certified Drinking Water HACCP Plan in order to develop a single integrated plan – an action that is endorsed by the Panel and one that must be in place before the *Water2WATER* scheme is implemented.

b. Quality of water from LMWQCC

It is essential to know the quality of the water currently produced at LMWQCC, as the quality of this water will impact on the design and effectiveness of the proposed purification process.

The parameters that are currently monitored for at the LMWQCC are summarised in Table 4 below. The Panel notes that the level of monitoring currently in place at LMWQCC exceeds that at most large wastewater treatment plants in Australia and overseas, but does not meet the extensive monitoring that is required for a purification plant for potable re-use.

Table 4: Summary of Parameters monitored at LMWQCC

Physico Chemicals	**Nutrients**	**Metals**	**Ions**	**Micro**	**Organics**
Alkalinity	Ammonia	Antimony	Calcium (soluble)	Faecal coliforms	Volatile organic carbon
Biochemical oxygen demand	Nitrogen (total, total Kjeldahl and total oxidised	Arsenic	Chloride		Monoaromatic hydrocarbons
pH	Orthophosphate	Beryllium	Copper (soluble)		Volatile organic carbons
Chemical oxygen demand	Phosphorus (total and soluble)	Boron	Cyanide		Polycyclic aromatic hydrocarbon
Chemical oxygen demand (soluble)		Cadmium	Fluoride		Phenols
Chlorine residual (total, combined, total 4 day average and free)		Chromium	Iron (soluble)		Organochlorine pesticides
Daily total flow		Cobalt	Magnesium (soluble)		Oil and grease
Dissolved organic carbon		Copper	Potassium (soluble)		Organophosphate pesticides
Electrical conductivity		Iron	Sodium (soluble)		Disinfection by-products
Hardness (Calcium and total		Lead	Sulphate		Polychlorinated biphenyl
Instantaneous Effluent flow		Manganese	Sulfide		1,2-Dichloroethane
Oil and grease		Mercury	Zinc (soluble)		1,2-Dibromethane
Methyl Blue active substances		Nickel			1,3-Butadiene
Suspended solids		Selenium			Acetic Acid
Temperature		Silver			Acetone
Total dissolved salts (calculated)		Zinc			Acrylamide
Total dissolved solids					Acrylonitrile
Total organic carbon					Carbon disulphide
Turbidity					D-(2-ethylhexyl) phthalate
					Dibutyl phthalate
					Dichloromethane
					Ethanol
					Ethylene glycol
					Ethylene oxide
					Methanol
					Methyl ethyl ketone
					Methyl isobutyl ketone
					Methyl methacrylate
					n-Hexane
					Tetrachloroethylene
					Trichloroethylene
					Vinyl chloride monomer

The frequency of sampling and subsequent analysis varies from daily for the physico-chemical attributes and nutrients, to quarterly and annually for the others and is specified in the Authorisation from the EPA.

A summary of the more “routine” parameters measured in the water leaving LMWQCC is presented in Table 3 in Section 2d above.

The panel notes that in terms of the routine, conventional wastewater parameters, the water leaving LMWQCC is of a very high quality and can be safely used for irrigation on recreational areas and for plant crops. It is, however, not suitable for drinking without further treatment

The range of microbiological parameters and organic parameters that are measured would have to be vastly expanded to include a wide range of health related microbiological parameters if *Water2WATER* is to proceed.

For example, only one microbiological indicator is currently monitored for – *Faecal Coliforms* – and while this has been traditionally used as an ‘indicator’ of many bacterial pathogens of concern, it has been shown to be an ineffective indicator for protozoan and viral pathogens which are important considerations whenever the more advanced forms of reuse, such as augmentation of drinking water supplies with purified water, are being considered and which can be present in effluents from plants such as LMWQCC. It is for this reason that many ‘emerging pathogens’ are now being monitored for in all of the indirect potable reuse (IPR) applications and the Panel recommend that the range of microbiological analyses be expanded to include, *at a minimum*, the following organisms:

- Cryptosporidium parvum, Campylobacter, Rotavirus – this would enable the Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (2006) to be used as the source of criteria for assessing acute health risks; and
- Clostridium perfringens, Somatic coliphage, Male-specific coliphage, Giardia lamblia, E. coli., and Enteroviruses.

The Panel has also reviewed the analytical results for the organic compounds listed in Table 4 over the period January 2000 to April 2007 and Table 5 compares the maximum results obtained with the Health Related Guideline Value (HRGV), where available, that is identified in the AGRW (NRMMC and EPHC, 2007) and the HRGV identified in the ADWG (NHMRC, 2004).

The panel notes that all analysis is carried out by NATA registered laboratories.

Table 5: Comparison of LMWQCC effluent organic chemicals (Maximum values) with Guideline Values (GVs)

Organics	**Max Value ug/L**	**AGWR ug/L**	**ADWG ug/L**
1,4 Dichlorobenzene	<0.1	nv	40
Benzene	<0.1	nv	1
Bromodichloromethane	4.5	250	nv
Bromoform	<0.1	250	nv
Carbon Tetrachloride	<0.1	nv	3
Chloroform	16	250	nv
Dibromochloromethane	3.4	250	nv
Dichloromethane	3.5	4	4
N-nitrosodiethylamine	<0.1	0.01	nv
Screen PAH	<0.1	nv	nv
Pentachlorophenol	<0.1	50	0.01

Phenol	<1	150	nv
Trichloroethylene	<0.1	nv	nv
Organochlorine Pesticides			
Aldrin	<0.1	nv	0.01
BHC	<0.01	0.41	nv
Chlordane	<0.01	1	0.01
DDD	<0.01	nv	nv
DDE	0.02	1	nv
DDT	<0.01	20	0.06
Dieldrin	<0.01	nv	0.01
Endosulfan	<0.01	nv	0.05
Endrin	<0.01	nv	nv
HCB	<0.01	nv	0.07
Heptachlor	<0.01	nv	0.05
Heptachlor-Epoxide	<0.01	nv	0.05
Lindane	<0.01	20	0.05
Methoxychlor	<0.01	nv	0.02
Oraganophosphorus Pesticides			
Azinphos-methyl	<0.02	3	2
Chlorpyrifos	<0.02	10	10
Demeton-S-Methyl	<0.02	0.15	nv
Malathion	<0.02	50	nv
Parathion	<0.02	10	10
PCBs	<0.1	nv	nv
DBPs			
Trihalomethanes (Total)	27	nv	250
CHBr2Cl	3	nv	nv
CHBr3	2.4	250	nv
CHBrCl2	6	250	nv
1,1,1,2-Tetrachloroethane	<0.1	nv	nv
1,1,2-Trichloroethane	<0.1	nv	nv
1,1-Dichloroethane	<0.1	nv	nv
1,1-Dibromomethane	<0.1	nv	nv
1,3-Butadiene	<0.1	nv	nv
Acetic Acid	<0.1	nv	nv
Acetone	<0.1	nv	nv
Acrylamide	<0.1	nv	0.2
Acrylonitryl	<0.1	nv	nv
Carbon Disulphide	<0.1	nv	nv
Chloroethane	<0.1	nv	nv
Cumene	<0.1	nv	nv
D-(2-ethylhexyl)phthalate	<0.1	nv	nv
Dibutyl Phalate	<0.1	nv	nv
Ethanol	<0.1	nv	nv
Ethylbenzene	<0.1	nv	300
Ethylene Glycol	<0.1	nv	nv

Ethylene Oxide	<0.1	nv	nv
Methanol	<0.1	nv	nv
MEK	<0.1	nv	nv
Methyl Isobutyl Ketone	<0.1	nv	nv
Methyl Methacrylate	<0.1	nv	nv
n-Hexane	<0.1	nv	nv
Styrene	<0.1	nv	30
Tetrachloroethylene	<0.1	nv	nv
Toluene	<0.1	nv	800
Total VOCs	<0.1	nv	nv
Trichlorethylene	<0.1	nv	nv
Vinyl Chloride monomer	<0.1	nv	0.3
Xylenes	<0.1	nv	600
PAHs			
Anthracene	<0.1	150	nv
Benzo(a)anthracene	<0.1	nv	nv
Benzo(a)pyrene	<0.1	0.01	nv
Benzo(b)fluoranthene	<0.1	nv	nv
Benzo(g.h.i)perylene	<0.1	nv	nv
Benzo(k)fluroanthene	<0.1	nv	nv
Chrysene	<0.1	nv	nv
Dibenzo(a.h)anthracene	<0.1	nv	nv
Fluoranthene	<0.1	4	nv
Fluorene	<0.1	nv	nv
Indino(1,1,1-cd)pyrene	<0.1	nv	nv
Napthalene	<0.1	70	nv
Phenanthrene	<0.1	150	nv
Pyrene	<0.1	150	nv

Source: Ecowise Report, 12 June 2007 *Note: 'nv' means 'no value given'*

It is not clear to the panel how the range of analytes was selected but Table 5 shows that many of the compounds were reported as being below limits of detection and many of them do not have associated HRGVs in either the ADWG (NHMRC, 2004) or the AGWR (NRMMC and EPHC, 2007). However, where values are reported, and there are associated HRGVs in the two Guidelines, the measured values are all below the associated HRGV.

The Panel notes that this is in line with experience elsewhere in Australia and should be taken into account in any assessment of long term (i.e. chronic) heath risk impacts, particularly as there will be a membrane-based WPP to further treat the water from LMWQCC. This issue is further discussed in Section 5.

The panel is also aware of a study that was carried out at the Australian National University (ANU) by Stuart Dennis in 2004 to evaluate the fate of Endocrine Disrupting Compounds in the LMWQCC. The study confirmed that LMWQCC appears to function similarly to other WWTPs in that biological treatment removes some of the estrogenicity of the influent water but there is still a presence of estrogenic activity in the effluent. If the *Water2WATER* project is to proceed, the monitoring programme will need to be more focussed and the nature of the organics tested for expanded to include estrogenic steroids, pharmaceutical degradation products, hormones and persistent industrial chemicals as well as a wide range of disinfection by-products.

The performance of the proposed water purification plant to be located at the LMWQCC is discussed in Sections 4c and d below, while the extent of the monitoring programme is discussed in Sections 5e and 6 below.

c. Removal of possible contaminants in the purification plant

Possible contaminants of concern in the water from LMWQCC are listed in Table 6.

Table 6: List of possible contaminants in treated LMWQCC water

Infectious agents	• Parasites including protozoa and helminths • Bacteria • Viruses • Prions
Chemicals	• Inorganic Salts • Nutrients • Disinfection by-products • Heavy metals including lead, mercury and cadmium • Organic compounds including volatile organic compounds (VOCs) and N-nitrosodimethylamine (NDMA) • Bacterial toxins (including cyanobacterial algal blooms) • Pesticides • Hormones • Radioactive chemicals • Pharmaceuticals

The ‘infectious agents’ (microorganisms) are all associated with ‘acute’ (or short term) risk while many of those listed under ‘chemicals’ are generally associated with ‘chronic’ (or long-term) risks.

It is important that these contaminants are effectively removed from the water during the purification process and before the purified water enters the Cotter Reservoir and Mt Stromlo WTP.

The treatment train proposed by ACTEW and which has been described in Section 3b has been selected by ACTEW to remove the contaminants of concern. The Panel notes that the proposed treatment train is similar to WPP operating overseas and to those currently being constructed as part of the Western Corridor Scheme in South East Queensland. In addition, the proposed treatment train has been identified in the AGWR (NRMMC and EPHC, 2007), as being capable of producing water that can be recycled with minimal risk. Refer to Section 4d below for further discussion on this topic.

The technical literature abounds with research papers and full-scale operational results that confirm the ability of the technologies proposed to reduce the wide range of possible contaminants to very low levels and in many cases to below the detection limits of modern day analytical equipment. Compliance with drinking water quality regulations can be readily proven.

It will be noted from Section 3b that the proposed WPP is based on the multiple-barrier concept in that there is more than one process unit to address each group of potential contaminants. Adoption of this multiple barrier approach results in there being no loss in product water quality if there is a reduced performance of one of the barriers.

Adoption of the multiple-barrier concept to treatment will reduce the variability in performance that can be experienced with single-barrier plants. Further, the Panel notes that the reliability of such multiple-barrier plants is generally such that plant shutdown – which is the ultimate safeguard against the introduction of a sub-standard water to the water cycle – is an unusual event.

Table 7 is a summary of the expected removal performance of each of the barriers in the proposed WPP in removing the potential contaminants listed in Table 6. This Table has been constructed by the Panel using data gathered from similarly configured water purification plants in Singapore, Orange County (USA) and San Diego (USA), as well as material published in the AGWR (NRMMC and EPHC, 2007) and the *Queensland Water Recycling Guidelines* (EPA, 2005).

Table 7 also summarises the overall removals expected for the three sets of potential contaminants; in terms of 'Log Removal' for the *microbiological* parameters and 'Expected Removal' for the *conventional wastewater indicators* and the *chemical compounds*. 'Log removal' denotes reductions in contaminants on a logarithmic scale ie-log 4 is a reduction to one ten-thousandth of the original concentration.

The Panel notes that the table shows that greater than 11 Log removal (10^{11}) can be expected for the microbiological parameters which is far in excess of the minimum log removals recommended in the AGWR (NRMMC and EPHC, 2007), namely 8 Log for the parasite *Cryptosporidium*, 9.5 Log for enteric viruses and 8.1 Log for the bacteria *Campylobacter* in drinking water augmentation applications.

Further, the removals for the other two groups of contaminants will be such that they are either below detection or are well below the calculated guideline value presented in the AGRW (NRMMC and EPHC, 2007).

Table 7: Multiple Barriers for Complete Water Cycle

Contaminants	Source Control *(i)*	LMWQCC	Water Purification Plant: Micro-/Ultra-Filtration (MF/UF)	Reverse Osmosis (RO)	Advanced Oxidation (AOP)	Chlorination	Overall Removal	Wetlands	Cotter Reservoir	Stromlo WTP
Microbiological - Log Removals (ii):										
* Parasites	n/a	0.5 - 3.5	5 - 6	4 - 6	4 - 6	0.5 - 1.5	14 - 23	0.5	1-3.5	2
* Bacteria	n/a	1 - 4	3.5 - 6	4 - 6	4 - 6	2 - 6	14.5 - 28	0	1 - 5	4
* Viruses	n/a	1 - 5	1.5 - 4	4 - 6	4 - 6	1 - 3	11.5 - 24	0	1 - 4	4
* Phages	n/a	1.5 - 5	1.5 - 4	4 - 6	4 - 6	0 - 2.5	11 - 23.5	0	1 - 4	-
* Helminths	n/a	2 - 5	>6	4 - 6	4 - 6	0 - 1	16 - 24	1	1.5 - 3	4
Conventional Wastewater Indicators (iii):										
Biological Oxygen Demand (BOD)	A	2	1	3	3	1	4	1	1	n/a
Total Organic Carbon (TOC)	A	2	1	3	3	1	4	1	1	1
Suspended Solids	A	2	3	3	n/a	n/a	4	n/a	1	2
Chemical Compounds (iii):										
* Dissolved Inorganic Salts	A	n/a	n/a	3	n/a	n/a	3	n/a	n/a	n/a
* Nutrients	A	2	1a	2	2	n/a	3	1	1	2
* Heavy Metals	A	2	1a	3	n/a	n/a	4	0	0	1
* Disinfection Byproducts	n/a	n/a	n/a	2	3	n/a	4	0	0	n/a
* Organic Compounds (incl NDMA, 1-4 Dioxane, VOCs)	A	n/a	n/a	2	3	n/a	4	1	1	n/a
* Bacterial Toxins	n/a	n/a	1a	3	3	n/a	4	0	0	1
* Pesticides	A	2	1a	3	3	0	4	0	0	0
* Hormones	A	2	1a	3	3	0	4	0	1	0
* Radioactive Chemicals	A	1	n/a	2	2	0	4	0	0	0
* Pharmaceuticals	A	2	1a	3	3	0	4	0	0	0

Notes:

(i) Applicable for parameters marked such - A

(ii) Removals given in 'Log Removals' - 1 Log = 90% removal, 2 Log = 99% removal.

(iii) Removals:

n/a : Not applicable - treatment process not relevant for this application
0 : No reduction: < 5% removal across the process
1 : Partially effective: up to 50% removal across the process
1a:Removal as for 1 but requires coagulane addition ahead of the process units
2: Effective: 50 - 90% removal across process
3: Very effective: Removal, with further reduction of >99% possible under some conditions
4: Overall treatment train removal greater than 99%

d. Quality of purified water leaving purification plant

The Panel notes that the draft AGWR (NRMMC and EPHC, 2007) in addressing microbiological and chemical risks states the following:

Microbiological Risk:

> *"Drinking water augmentation schemes will typically include high levels of treatment. A treatment train **incorporating membrane filtration, reverse osmosis and advanced oxidation** will provide log reductions that exceed the minimum requirements. Hence residual risk will be acceptable subject to good management."*

Chemical Risk:

> "*There are relatively large amounts of Australian and international data for inorganic chemicals in untreated and secondary treated sewage. Exceedances of drinking water guideline values have occasionally been found for maximum concentrations reported for inorganic chemicals but the 90th and 50th percentile concentrations are generally in compliance. Treatment processes such as **reverse osmosis** and **activated carbon** would effectively reduce concentrations of inorganic chemicals.*
>
> *Available data for organic chemicals indicated that there were exceedances for a limited number of disinfection by-products, pesticides and trace organics. The largest exceedances were for the disinfection by-product NDMA, the pesticide Demeton S, the dioxin-like compounds OCDD and DCDD and paraxanthine and benzo (a) pyrene. OCDD has a toxicity equivalent factor of 0.0001 (NHMRC, 2002) and represents one of the least potent of the dioxin-like compounds while DCDD is not currently classified as having dioxin-like activity.*
>
> ***Reverse osmosis** will remove pesticides and compounds such as paraxanthine while the disinfection by-products, dioxins and benzo(a)pyrene can be removed by combinations of reverse osmosis and advanced oxidation.*
>
> *Hormones pharmaceuticals and endocrine disruptors*
>
> *Pharmaceuticals and natural hormones excreted by humans on a daily basis and compounds identified as having endocrine disrupting activity are generally present in low concentrations (compared to guideline values) in secondary treated sewage.*
>
> *The majority of hormone and pharmaceutical concentrations detected in secondary treated sewage are well below the calculated guideline values. Concentrations detected in secondary treated sewage are typically greater than 10 fold and in many cases greater than 1,000 fold below the calculated guideline values. The exceptions are mestranol and methotrexate. The concentrations of both of these compounds would be reduced to below guideline values by **advanced treatment including reverse osmosis.***

The panel considers that with the anticipated quality of feedwater from the LMWQCC, as discussed in Section 4b and with the treatment train proposed and discussed in Section 3a, the four quality objectives as specified by ACTEW (see Section 3a) will be met, provided appropriate operation and management procedures are in place.

Sustained removal of all contaminants will only occur if the various treatment stages are operated and maintained in optimum condition in the long-term and the Panel recommends that ACTEW provide the following material for approval before the process is commissioned:

- The staffing levels proposed for the new plant;
- The level of training that the plant operators will have undergone prior to plant commissioning;
- The means by which the operation of each of the stages of treatment is monitored and maintained at the optimum level (eg where relevant, details of membrane integrity testing, specialised on-line instruments etc); and
- An approved HACCP Plan that shows the likely Critical Control Points (CCPs) for the various stages and barriers in the WPP, together with 'action' and 'shutdown' values.

The panel expects that the proposed new WPP will be designed for continuous operation, noting that the technologies proposed by ACTEW do not lend themselves to being frequently taken off-line for extended periods of time. In addition, it notes that in other similar purification applications, it is the 'time on line' that is the main means of controlling the unit cost of production.

e. Effects of transport to and storage in Cotter Reservoir on water quality

i. Wetlands

The Panel has not as yet reviewed the proposals for the wetlands but understands that the purified water will be pumped to some 5 Ha of shallow open lagoons that will have macrophytes growing in them. It further understands that there will be a hydraulic gradient of some 50m through the wetlands to the reservoir.

The Panel further understands that one of the main functions of the wetlands is one of 'temperature equalization', in order to ensure that temperature-driven short-circuiting is minimised in the Cotter Reservoir, rather than one of nutrient reduction.

The Panel considers that with the level of treatment built into the water purification plant and with the quality of water that will be produced, there will be little to no advantage achieved, from a purification point of view, by passage through the proposed wetlands. Under summer conditions, some nutrient reduction may be possible within the wetland. However, it does concur that there is a need to avoid temperature-driven short-circuiting in the Cotter Reservoir.

Water will exit the wetlands and flow for another 1.5 kms before entering the enlarged Cotter Reservoir.

ii. Cotter Reservoir

The Panel understands from ACTEW that the purified water will still contain both nitrogen (N) and phosphorus (P) concentrations (0.7 and 0.05 mg/L respectively), while the current N and P values in the reservoir water, over the 12 m depth, range from 0.18-0.21 mg/L Total Nitrogen (TN) and 0.013-0.015 mg/L Total Phosphorous (TP).

The Panel understands that there has not been a study carried out to establish if these expected TN and TP loads in the purified water will encourage water blooms of cyanobacteria within the reservoir water, or indeed if higher values could be tolerated before such growths occur. The Panel is aware of a surface water augmentation project in the USA where the addition of nitrate in purified water has been shown to be of benefit to the aquatic environment within the receiving reservoir.

The primary relationship between cyanobacterial proliferation and nutrient concentration in reservoirs is determined by phosphorus concentration, with limited probability of bloom formation below 0.01-0.02 mg/L of total phosphorus (Falconer, 2005). At present the reservoir has a phosphorus concentration below this level, however with substantial input of water at 0.05mg/L TP, a raised phosphorus concentration in the reservoir will result. This process can be modelled, and it is recommended that this be done in parallel with a study of the possible biological consequences of the nutrient loading.

If there is a likelihood of cyanobacterial blooms, the addition of a Powdered Activated Carbon (PAC) facility to the Mt Stromlo WTP should be considered as a contingency measure.

f. Quality of drinking water from Mt Stromlo WTP

The treatment technologies installed at the Mt Stromlo WTP are described in Sections 2c and 3d and act as additional barriers in themselves. The Panel considers that the quality of water produced by the WTP will continue to meet the ADWG (NHMRC, 2004) if *Water2WATER* proceeds.

However, the panel suggests that provision be made to dose PAC at the Mt Stromlo WTP if there is evidence of cyanobacterial outbreaks in the Cotter Reservoir water.

5. Risk Management

a. *Concepts and measures of 'risk'*

'Risk' refers to both the likelihood (statistical probability) of some future event occurring and to the magnitude of the impact (consequence) of that event. We say, for example, that there is little risk (probability) of being run over if we cross with the green traffic light. We also say it is less risky (lower impact) to be run over by a cyclist than by a bus. Thus, 'risk' is a composite concept – often not easy to quantify, and often difficult to communicate to the general public.

i. Risk assessment: categories from Australia's published guidelines

The draft AGRW (NRMMC and EPHC, 2007) provides a two-dimensional matrix (Tables 8-10 below), combining both likelihood and consequence for assessing the level of risk that pertains in any given setting. See the following:

Table 8: Qualitative measures of likelihood

Level	Descriptor	Example description
A	Rare	May occur only in exceptional circumstances
B	Unlikely	Could occur at some time
C	Possible	Might occur or should occur at some time
D	Likely	Will probably occur in most circumstances
E	Almost certain	Is expected to occur in most circumstances

Table 9: Qualitative measures of consequence or impact

Level	Descriptor	Example description
1	Insignificant	Insignificant impact, little disruption to normal operation
2	Minor	Minor impact for small population, some manageable operation disruption, some increase in operating costs
3	Moderate	Minor impact for large population, significant modification to normal operation but manageable, operation costs increased, increased monitoring
4	Major	Major impact for small population, systems significantly compromised and abnormal operation if at all, high level of monitoring required
5	Catastrophic	Major impact for large population, complete failure of systems

Table 10: Qualitative risk analysis matrix – level of risk

	Consequences				
Likelihood	**1.Insignificant**	**2. Minor**	**3. Moderate**	**4. Major**	**5.Catastrophic**
A (rare)	Low	Low	Moderate	High	High
B (unlikely)	Low	Low	Moderate	High	Very High
C (possible)	Low	Moderate	High	Very High	Very High
D (likely)	Moderate	High	High	Very High	Very High
E (almost certain)	Moderate	High	Very High	Very High	Very High

This composite character of 'risk' means that it is difficult to assign a single, summary, level of public health 'risk' to the proposed additional water treatment process. There are variations in both the probability and seriousness of a wide range of different hazards, microbiological chemical and other. Estimating an 'average' level of risk, across these several dimensions, is not really meaningful.

As discussed below, for normal operation of the system the expectation is that the likelihood of exposures in drinking water with health consequences of level 3 or above (Table 9) is very unlikely (levels A/B in Table 8). However, the prospect of a serious system failure, for which the likelihood can be presumed from experience elsewhere and from the multi-barrier system here proposed to be rare (A), raises the possibility of a much more serious public health consequence (levels 4/5, Table 9) – most plausibly via an outbreak of waterborne infectious disease. Such a failure, occurring in a large city such as Canberra, could readily result in tens of thousands of people, or more, being exposed to pathogens.

Therefore, combining both these considerations (i.e., of normal operation and of potential system failure), and focusing particularly on the possibility of an outbreak of waterborne infectious disease, a prudent conclusion would be to regard this proposal as "High Risk". That has great implications for the choice and intensity of system monitoring procedures, as is clearly identified in the AGWR (NRMMC, 2007) and as the Panel has identified in this Report.

ii. Limiting, but not eliminating, risk

We cannot eliminate risks to our health; risk is inherent in being alive. Unforeseen events occur, random damage can occur, and mistakes are made. Guarantees of absolute and permanent safety and fully protected health can therefore never be given; rather, society strives to minimise risk.

The task, therefore, is to reduce the specified type of risk to at least the level that society agrees is acceptable (or 'tolerable'). We set speed limits in order to minimise risks on the roads – in order to achieve a level of safety that society has agreed upon. The roads are thus rendered not perfectly safe, but acceptably safe.

On some accounts, 'risk' also includes a third, subjective, component. One of the world's leading risk researchers, Sandeman, has proposed that 'risk' is the product of objective 'hazard' and subjective 'outrage'. The 'outrage' refers to the fact that we are less accepting of certain categories of hazard – because, for example, we cannot see or smell the hazard, or it reaches us via water and food, or it comes from some adversarial or suspect party, etc. This subjective aspect has clear relevance in the *Water2WATER* context because concerns about contaminants in drinking water lie deep in the human psyche. The human desire for clean safe drinking water transcends time and culture.

That subjective dimension, however, will not be further considered here. Its importance is recognised – indeed that is one basic reason for the existence of this report. But this report will seek to make an objective assessment of the types and levels of risk that exist, or could exist, from the proposed purification of water produced by the LMWQCC.

Social agreement on what constitutes 'safe' drinking water is necessarily complex, in part because of the huge range of possible physical, chemical and microbiological contaminants, and in part because risk can arise from both the normal operation of water treatment process and from failure of that system. The specification of requisite standards for each of the known potential water-borne hazards to health must then be undertaken on an itemised basis, along with the appropriate monitoring processes and schedules, and, in the event of system failure, emergency action plans appropriate to the assessed configuration of risk resulting from that failure.

This situation differs from other simpler situations of potential environmental exposure for which acceptable levels of exposure can be set in relation to a single factor known to cause a particular health outcome. A good example is that of defining 'acceptable' exposures to known cancer-causing chemicals. In Australia and the USA a one in one million lifetime risk of cancer is regarded as a tolerable risk. USA and Australian regulatory bodies limit general community exposures to specific compounds to levels that would cause no more than one cancer death per million persons per year. The data from which these risks are calculated are largely from animal exposure, with human occupational exposures used where these are available.

Interestingly, following the WHO drinking water guidelines, (p.154 Third Edition, 2004) Europe accepts a lifetime cancer risk of one in 100,000 people as the basis for calculation of acceptable risk, a tenfold higher level of risk from exposures to environmental carcinogens than the USA or Australia. This underscores further the subjective, or culturally determined, aspect of 'acceptable risk'.

Drinking water guidelines now emphasize both the need for process control, which has been formalized through HACCP accreditation, and Guideline Values (GVs) for specified contaminants, which quantify safe concentrations for lifetime exposure. The GVs for chemical contaminants are continuously revised, on the basis of new knowledge. Relatively less harmful chemical constituents of drinking water have higher GVs concentrations, and those with high toxic or carcinogenic potency very low concentrations. Large safety factors are incorporated into the determinations, based on toxicity or carcinogenicity. Microbiological risk is assessed on the basis of likelihood of exposure and severity of the disease, and can be based on the concept of Disability Adjusted Life Years (DALY). This represents both actual reduction in life expectation and the effects of illness. A risk of loss of one millionth of a DALY is regarded as a tolerable risk for microbiological pathogens.

Once the GVs are determined, the reduction in the contaminant that is needed for safe water can be calculated from the actual amounts of contaminant in the raw water supply. In most cases the levels of hazardous contaminants in raw water for drinking supply are so low that they cannot be measured. For example, ACTEW measures pesticide concentrations in the ACT drinking water reservoirs regularly, with the results that none can be detected. Hence no treatment for their elimination is required. If however a contaminant was detected in raw water at 100 times the allowed concentration, then the subsequent water treatment would be required to reduce the concentration by a factor of 100. This is often referred to in water treatment as 2-$\log_{10}$ removal, or "2 logs". This corresponds in popular idiom to "two orders of magnitude". The requirement for removal of chemical contaminants becomes greater when low quality water sources are employed, such as heavily used rivers, and those that receive industrial discharges or wastewater.

b. Types of health risk

i. Acute vs. chronic health effects from exposures in drinking water: epidemiological surveillance and analysis

Formal epidemiological study and analysis is required to identify any change in community health status that occurs in response to the use of purified water. Such changes in health outcome can be of an acute or chronic kind – i.e., respectively, occurring within a short time after the change in drinking-water exposure (e.g. diarrhoeal disease), or occurring months or years after the change in exposure (e.g. cancer, impaired organ function).

Acute health risks

The health impacts of episodes of unexpected (including accidental) increases in exposure to microbiological or chemical contaminants may be readily observable as outbreaks of acute adverse health effects. Such acute health impacts are most readily identified when there is a pre-existing systematic community-wide health-event notification scheme (eg for diarrhoeal disease – which, in all Australian States and Territories, is a notifiable disease).

To detect such eventualities, the essential comparison is made over time – either by observing a conspicuous acute surge in case numbers, or, for less dramatic impacts, via a formal time series analysis that compares disease rates over adjoining periods of time. Appropriate surveillance systems therefore need to be established, encompassing the possibilities of both marked and subtle changes in rates of adverse health outcomes occurring in immediate response to changes in the contaminant content of drinking water.

Via these means, any impacts of drinking water quality on acute infectious disease occurrence can be detected immediately, if the outbreak is widespread and severe, and relatively promptly if there is a non-trivial change (but no obvious 'outbreak') in the rate of occurrence.

In considering the health risks to consumers associated with wastewater purification, the microbiological risks require particularly careful assessment. The risks include the potential presence of pathogenic protozoa such as *Cryptosporidium* and *Giardia*, bacterial pathogens such as *Salmonella* and a variety of viruses that cause gastroenteritis. Many of these microorganisms are part of the everyday environment and are detected in large numbers in rivers and lakes, and we have all, at different times, had gastroenteritis. It can thus be assumed that these organisms are always present in wastewater, and that appropriate treatment will be essential if water purified from this source is to be incorporated in the drinking water supply. To assess the risk involved, and the extent of treatment necessary for safe water supply, two pieces of information are essential.

One is the extent or severity of the disease caused by the organism, the other is the concentration of these organisms contained in the purified water. To determine a safe concentration of the organisms requires a decision on tolerable or acceptable risk. A detailed example is given in the Box 7.

Box 7: Risk assessment, using DALYs: Example of the common protozoal infection *Cryptosporidium*

The microbiological risk from drinking water can be estimated by using a widely used measure of the amount of healthy life lost, the Disability-Adjusted Life Year (DALY). One DALY is equivalent to the loss of a year of life-in-good-health. Such losses occur either by dying prematurely or by developing a chronic disease/disability that corresponds to some agreed fraction of complete loss of health. In assessing health risks to a population, an acceptable (tolerable) level of risk is commonly regarded by government and community as the loss of one DALY per one million persons per year – that is, one millionth of a DALY per person per year can be regarded as a tolerable risk.

For chemical contaminants in drinking water, the severity of the health risk from toxicity is used to determine the upper acceptable concentration of contaminants. For pathogens in water, the assessment of risk to health depends on the severity of the ensuing infectious disease. Consider the following example for the common water-borne protozoal infection *Cryptosporidium.* Unlike bacterial and viral infections which need the consumption of numbers of organisms for infection, it can be assumed that the ingestion of one *Cryptosporidium* oocyst can cause infection and diarrhoea.

For a person infected by *Cryptosporidium* the loss of healthy life has been assessed (by WHO) to be 0.016 DALYs – i.e. one sixtieth of a DALY. This assessment is based on the actual adverse effects of the disease in otherwise healthy people. Hence, to prevent a population of one million persons breaching the agreed acceptable risk limit, the water quality would need to ensure that no more than sixty cases of cryptosporidioisis occurred in any one year. Assume a concentration of *Cryptosporidium* in untreated sewage of 2000 organisms per litre, the reduction in concentration required to provide an average risk of one millionth of a DALY per person per year is 8-$\log_{10}$ removal (i.e., a decrease in concentration by 8 'logs' – or 8 'orders of magnitude'). That achieves a reduction to 0.00001% of the original concentration, or 2 organisms in 100,000 litres of treated water.

This approach to calculating risk applies readily to routine exposures, such as the daily consumption of drinking water. However, it bears little direct relevance to many other actual personal human situations. For example, a short swim may result in swallowing enough organisms to cause diarrhoea.

There is no prescribed Guideline Value in Australia for *Cryptosporidium* in drinking water based on this risk assessment, due to the obvious difficulty of finding two microscopic cysts in 100,000 litres of water, and that of recognizing them as infective organisms when found. Similarly no Guideline Value has been set by WHO due to lack of effective detection methods. The WHO recommends a multiple barrier approach to *Cryptosporidium* reduction, in which each barrier provides a reduction in the possibility of the cysts passing through into the final water supply. In the USA the finding of more than one cyst in 100 litres of treated water in a series of averaged samples, results in scrutiny of the treatment processes, which have a target of less than 0.5 cysts per 100 litres. In the United Kingdom the average number of *Cryptosporidium* cysts permissible in drinking water has been set at less than 10 cysts per 100 litres of treated water, with daily monitoring. WHO have used a Tolerable Risk based on $1x10^{-6}$ DALYs per person per year in their calculations for *Cryptosporidium*, with a result of a tolerable concentration of $6.3x10^{-4}$ cysts per 100 litres of drinking water, but not set a guideline.

Using these approaches it is possible to define the concentration of organisms and substances in drinking water which provide a negligible risk to health, and hence the level of purification which has to be provided. This level of purification will depend on the initial quality of the raw water source, with wastewater sources requiring the highest level of purification.

Longer-term, non-acute, risks to health

Longer-term, non-acute, changes in the rate of occurrence of either biological harm (eg impaired liver function) or actual disease within the community are not immediately detectable. To detect any such health impacts, the appropriate epidemiological analysis compares rates of occurrence of the specified outcome. This comparison can either be between adjoining or otherwise comparable populations with differing levels of exposure to the recycled water supply, or (usually more difficult to interpret) across a long period of time.

For example, imagine that some chemical contaminant (not successfully removed by purification of the treated wastewater) causes a rise in incidence of cancer 'x'. By careful comparison, either over time ('after' versus 'before') or between communities consuming different types of drinking water, it is possible to detect differences in rates of cancer 'x' occurrence over time. Depending on time-relationships and the richness of information available on other possible factors that also influence cancer risks, it then becomes possible to assess whether the observed difference is attributable to the water quality itself.

Similarly, any adverse impacts on birth outcomes can be studied via systematic surveillance, relying on the ACT's population-based birth outcome notification scheme.

Conversely, effects on subclinical toxicity are more difficult to detect, and often require sequential bioassays and/or longer follow-up times before effects are detectable (e.g. heavy metal accumulation in kidney, brain and liver). Similarly pharmacological effects may be subtle, and assays/tests would need to be specific. In these cases, *in vivo* tests (e.g. mutagenicity, carcinogenicity) may be useful, but inconclusive with respect to actual risk in humans.

Results of previous epidemiological studies

There are few systematic epidemiological studies of health outcomes in relation to potable recycled water, from elsewhere, available for appraisal. This reflects both the practical difficulties in conducting community-level research in relation to the health impacts of drinking water treatment regimes and the relatively small number of systems that have been previously introduced elsewhere in the world and which have allowed sufficient time for accrual of evidence,

The three main epidemiological studies of direct relevance include a pair of studies (the Montebello Forebay Studies, 1 and 2) in relation to the consequences of Los Angeles County's recharging of its ground-water drinking water supply, starting in 1962, and a study in Windhoek, the capital city of Namibia, in south-west Africa, where the limitation of local water supplies necessitated the recycling of purified water from the mid 1960s.

- **Montebello Forebay Study 1** (Frerichs, 1984) . This epidemiological study, conducted within the greater Los Angeles metropolitan area, examined the health experience during 1969-1980 of approximately 480,000 persons with some level of exposure to the recycled component of the ground-water supply, compared with 630,000 persons with no such exposure. This total study population was categorised into four sub-populations, two from the 'exposed', two from the 'unexposed'. The comparison strategy was inherently of only modest strength since the household water supply to the 'exposed' communities typically contained no more than around 5-15% of the recycled water. Drawing on population-based birth, disease and death registers, health outcome rates over time were compared, including: mortality (all deaths, deaths from heart disease and stroke, deaths from all cancers, and deaths from stomach, colon, bladder and rectum cancers), various adverse birth outcomes, incidence of stomach, colon, bladder and rectum cancer, and some potential waterborne infectious diseases (including shigellosis and hepatitis A). The water supplies were also compared for *in vitro* mutagenicity. While some outcomes rates were higher in the exposed communities, others were lower. No clear picture emerged, and there were no evident dose-response relationships.

- **Montebello Forebay Study 2** (Sloss et al., 1996). This study added a second period (1987-1991) to the epidemiological follow-up of the above population – which had now increased in size. Five 'exposure' sub-populations were identified, with water supplies ranging from an average of near-zero to around 15% of household water deriving from the recycled source. Using the same population-based data sources as above, the follow-up extended the range of health outcomes, to include several less common cancers and more detailed information on birth outcomes. The investigators noted, also, that there had apparently been an increase in population mobility within the study region over the decades, and that this marginally weakened the strength of the comparisons made. As for Study 1, no clear differences in health risk between the exposure sub-populations was evident.

- **Namibia (southern Africa) Study** (Isaacson and Sayed, *SA Medical* J, 1988; du Pisani, *Desalination*, 2005). This epidemiological study examined the health effects, during the 1970s and 1980s, of the direct potable recycled drinking water system previously introduced in Windhoek, Namibia. There was no clear pattern of health risk from the Namibia study. The usefulness of this study, particularly in relation to the assessment of infectious disease risks, is low since the internal comparison was with the population of consumers of river water, known to be microbiologically contaminated anyway.

Khan and Roser (2007) have recently reviewed the several main published studies that have examined the use of purified recycled water in relation to possible subsequent toxicological and other health effects, with particular attention to the above three studies. They concluded that, despite more than forty years experience, no clear deleterious health effects from purified recycled water schemes have yet been observed.

The relatively recent development of RO means that time is needed to evaluate its performance via observational epidemiological studies of the kind described above that test for any associated health consequences. RO was first used in a water purification context in 1976 in Orange County, California where the purified water was blended into a groundwater aquifer that served as the water supply for the community (see http://gwrsystem.com). It is not possible, logistically, to conduct huge studies of new purification technologies that compare, in experimental fashion, similar populations simultaneously with and without RO-processed drinking water but do know that the quality of purified water produced by RO is of far superior quality to that produced by alternative non-membrane based technologies that were in application before that date.

ii. Security of drinking water supply

Water is essential to health and life. Water deprivation and the ensuing dehydration can be fatal. The other main public health risks of inadequate supply of drinking water include:

- poor personal hygiene: skin and hair (especially scalp) infections;
- the risks arising from alternative sources of drinking water;
- reduced baseline fluoride intake (dental health); and
- psychological consequences of degradation of public space – parks, playing fields, bushland – and private gardens.

iii. Safe disposal of effluent from purification of treated wastewater

A potential public health risk exists in relation to the need to dispose of wastewater from the RO process with its high concentrations of brine, salts, pathogens, drugs and other products. This requires additional risk assessment and risk management plans, in relation to both transport and disposal of these materials.

iv. Energy use, climate change and health

While this topic is under investigation by other groups, the Panel notes the following points as relevant to overall public health and safety.

A water purification plant that uses reverse osmosis has similarity to a desalination plant, where RO must be used to remove salt from seawater. It is however more energy efficient than seawater desalination, due to the lower osmotic pressure of wastewater. Both the purification process and the uphill pumping of the purified water will have a substantial energy demand, resulting in increased greenhouse gas emission. Unless 'green energy' is sourced, the purification process will contribute to the ongoing global increase in atmospheric greenhouse gas concentration and the rising risks to population health, near and far (McMichael et al., 2006)

c. Managing Risk

'Ensuring drinking water safety and quality requires the application of a considered risk management approach.'

'The process of keeping drinking water safe is one of risk management. This requires steering a sensible course between the extremes of failing to act when action is required and taking action when none is necessary. Lack of action can seriously compromise public health, whereas excessive caution can have significant social and economic consequences. Corrective action or system upgrades should be undertaken in a considered, measured and consultative manner. Failure to act when required (e.g. failing to shut down a system when disinfection is not working effectively) may lead to an outbreak of waterborne disease. Acting when not required (e.g. issuing a 'boil water' notice when that is not necessary) is usually less severe in the short term, but repeated occurrences of waste resources are likely to cause complacency in the long term, leading to failure to respond when it is truly necessary. Similarly, failing to install a treatment process when required could lead to waterborne disease; however, installing treatment processes that are not required could have a high financial cost and divert funds needed elsewhere.'

> *'Risk management is about taking a carefully considered course of action. As the obligation is to ensure safe water and protect public health, the balancing process must be tipped in favour of taking a precautionary approach.'*
>
> *Quotes from pp 1-3 ADWG (NHMRC, 2004)*

Risk management comprises, at its core, the set of water-borne exposure (concentration) standards, CCPs for system monitoring, and specified actions in response for under-performance or failure of the system. Many second-order decisions relating to infrastructure, staffing, budgets, quality control and others flow from this.

A system for managing risk, and which is embodied in the ADWG (NHMRC, 2004) and the draft AGWR (NRMMC and EPHC, 2007), is that of HACCP assessment that has been adapted in the water industry from the food manufacturers. This method of risk management is discussed further in Section 5d below.

To minimise the health risks from drinking water, it is essential to maximise the purity of the source of drinking water. However, there is no disinfection, sterilising process or chemical purification system that works perfectly, nor totally free of the possibility of some level of system malfunction. This presents a particular challenge when the inflow water is water that is itself a product of raw sewage.

i. Membranes and reverse osmosis: removal of salts, drugs and microorganism?

Removal of Microorganisms

Pathogenic water-borne microorganisms cause a range of adverse health outcomes varying in severity from mild gastroenteritis to severe and sometimes fatal diarrhoea, dysentery, hepatitis, cholera and typhoid fever. It is therefore of great importance to ensure protection against the various microbes ('pathogens' – bacteria, viruses and protozoa) that are able to cause infectious disease in humans. This is particularly so when the context entails the following points of vulnerability:

- An ageing population;
- An increasing prevalence of immune-compromised persons (including those who have had organ or tissue transplants);
- The possibilities of pathogen multiplication in a recycling water supply; and
- Some evidence (or at least the possibility) that pathogen strains with heightened resistance to chemical purification processes can 'emerge'.

The ADWG (NHMRC, 2004) states: "The greatest risks to consumers of drinking water are pathogenic micro-organisms. Protection of water sources and treatment are of paramount importance and must never be compromised."

Note, however, that water that contains tiny residual numbers of infectious agents poses no risk of infection: all the water that we routinely drink, whether from tap or bottles, contains at least a few bacteria and viruses. For infection to occur from a particular microorganism, a minimum infective dose is usually required to be consumed, of the order of many hundreds or thousands of that bacterium or virus. The situation differs for protozoans such as *Cryptosporidium parvum* and *Giardia lamblia* where relatively few organisms can cause infection.

Drugs, Sex hormones and Endocrine Disruptors

Endocrine-disrupting compounds (EDCs) can either disrupt normal hormone function or mimic hormones in ways that produce an unnatural response. In addition to wastewater containing sex steroid hormones flushed down toilets or present (as metabolites) in human urine, various environmental oestrogenic chemical molecules (from pesticides, detergents and some prescription drugs) can mimic the human female oestrogen. Modern RO and advanced oxidation treatment should remove all such organic chemicals. However, residual uncertainties about aspects of system performance will necessitate continuing vigilance.

The multi-barrier, dual membrane, process train proposed by ACTEW will comprise equipment and membranes that are technologically very advanced. Under normal operation, that system, given the documented specifications and performance elsewhere, should provide effective protection against the many potential hazardous physical, chemical and microbiological exposures present in wastewater – as is outlined in Section 4d and summarised below:

- For microbiological risk, a treatment train incorporating MF, RO and advanced oxidation will provide log reductions that exceed the minimum requirements;
- For chemical risk, treatment processes such as RO, activated carbon and advanced oxidation would effectively reduce concentrations of organic chemicals;
- RO will remove pesticides and compounds such as paraxanthine while the disinfection by-products, dioxins and benzo(a)pyrene can be removed by combinations of reverse osmosis and advanced oxidation; and
- The concentrations of hormones, pharmaceuticals and endocrine disruptors, would be reduced to below guideline values by advanced treatment including RO and advanced oxidation.

This is supported by the eWater CRC *Issues Discussion Paper* (eWater CRC, 2007), which concludes that:

> "Our preliminary scan of the international literature indicates that a well designed and well operating 'Option A' type system (MF/UF+RO+UV/H2O2) *has the potential* to remove all viral and bacterial contaminants and organic pollutants, and to reduce salts, nutrients and heavy metals to concentrations similar to, or lower than, that found in natural catchment run-off. This assumption will be further tested and evaluated through more detailed scientific review during preparation of the Stage 2 Technical Report."

Other considerations pertaining to risk management

In addition to considerations of normal system operation, there is always the risk, in principle, that system malfunction may occur. There have been recent reported outbreaks of water-borne infections in the USA, Canada and Europe due to both human failure and equipment failure, although these involved simpler water treatment processes (chlorination, filtration, flocculation, etc), unprotected by multiple barriers. Clearly, ACTEW must incorporate and implement rigorous provisions for detecting failure of any and all system components, to ensure that there is no break-through or leakage of incompletely purified water, as discussed in Section 5d.

ACTEW proposes to use the whole wastewater flow for purification and then recycle the water produced. This currently includes all domestic and non-domestic, including industrial, wastewater. Careful control of discharge to sewers will be required. WPPs elsewhere exclude industrial wastes from the plant inflow, and this necessarily constrains the evidentiary basis on which to judge the efficacy and safety of this new proposal.

d. HACCP and Operational Monitoring

The ACT drinking water treatment operates to the ADWG (NHMRC, 2004). These guidelines include HACCP accreditation, multi-barrier treatment technology, and extensive concentration guidelines for contaminants, both microbiological and chemical.

ActewAGL, who operate Canberra's drinking water treatment plants on behalf of ACTEW, has a third party certified HACCP system in place for the management of the whole present drinking water system – from 'catchment to tap'.

As noted in Section 4a this overall HACCP plan must be extended to include the trade waste input management and surveillance processes in order to develop a single integrated plan. The Panel also notes that this integrated HACCP Plan must also include the LMWQCC and, should *Water2WATER* proceed, the WPP and the transport system to Cotter Reservoir.

The Panel expects that the WPP will be operated for optimal performance as indicated on p.26 and staffed for 24 hours/day for at least the first 5 years of its life, whereafter experience will dictate whether or not the plant can operate unmanned for periods of the day – with the proviso that there be automatic call-out facilities activated in the case of a process malfunction.

Further, The Panel recommends that ACTEW incorporate the CCPs for the operational monitoring of the WPP into the plant's HACCP Plan as well as an overall Recycled Water Management Plan for the *Water2WATER* proposal. The various components of the Recycled Water Management Plan that relate to each stage or barrier in the *Water2WATER* proposal should be similar to those shown in Figure 5, which has been adapted from the version prepared for the Queensland Water Commission in February 2007.

Figure 5 shows that the operational performance of each stage or barrier in the *Water2WATER* proposal is assured through two levels of monitoring, one with on-line instruments (that are the basis for the CCPs in the HACCP Plan) and the other through laboratory analyses. In addition, there are also *contingency* steps that can be taken at each barrier to safeguard the performance of the downstream barrier if a malfunction in a component of a particular barrier is identified, such as pump failure, membrane integrity failure etc.

It will be noted that the 'ultimate' contingency is 'Shutdown AWT'. The Panel therefore considers that if the steps outlined in Figure 5 are implemented in the *Water2WATER* proposal, there is very little chance that sub-quality water will ever be transported to Cotter Reservoir.

	On-line monitoring	Lab monitoring	Contingency
Barrier 1 Source control	• pH • VOC analysers	• Trade wastes • WWTP influent	• Agreements & regulations • Communication
Barrier 2 Lower Molonglo WQCC	• pH • Ammonia • Nitrate • Turbidity • Temperature • Conductivity	• WWTP effluent • Analyses	• Feedback to WWTP ops. • Shutdown AWTP
Barrier 3 Microfiltration or Ultrafiltration	• Turbudity • Conductivity • pH • Particle count • Combined chlorine • ORP • Membrane integrity test	• Turbidity • Conductivity • Combined chlorine	• Start up redundant units as required, or • Shutdown AWT
Barrier 4 Reverse osmosis	• Conductivity • TOC • pH • Turbidity	• pH • Conductivity • Selected PRW parameters	• Redundant module start up, or • Shutdown AWT
Barrier 5 Advanced oxidation	• Peroxide dose • UV dose • UV transmissivity	• PRW quality as per RWMP • TN & TP • Nitrate	• Shutdown AWT
Barrier 6 Blending of purified recycled water into Cotter Reservoir	—	• Biota diversity & health • Chlorophyl 'a' • Analyses • Cyanobacteria	—
Barrier 7 Water treatment plant	• Turbidity • Chlorine • UV dose • pH • UV transmissivity	• Compliance with ADWG	• Powdered activated carbon • Shutdown WTP

Source: Adapted from version prepared for Queensland Water Commission, February 2007.

Figure 5: Recycled Water Management Plan & HACCP

e. Verification Monitoring at the Water Purification Plant.

Water quality testing is an important adjunct to any IPR scheme, as identified in the draft AGWR (NRMMC and EPHC, 2007) as it enables the proponent to verify that the purified water produced complies with the relevant standards that are promulgated by various agencies. In addition, the Panel notes that there will also be the necessity to analyse for compounds that are as yet not covered in the ADWG (NHMRC, 2004) but are raised in the draft AGWR (NRMMC and EPHC, 2007) and the Panel expects ACTEW to draw up a comprehensive list of all compounds that are to be reported on for both the feedwater and for the purified water transported to Cotter Dam.

Where possible, the GV for each of the compounds to be monitored in the purified water must be identified. In addition, the laboratories that will be carrying out the analyses must be identified and the Panel expects that they will all be NATA registered for the tests that they have been selected to carry out.

For example, The Panel notes that the following parameters are currently monitored in both the source and product water at each of the NEWater Plants in Singapore as part of the NEWater Sampling & Monitoring Programme (SAMP) – a total of 292 different parameters:

- Physical Characteristics (9);
- Inorganic Chemical Agent & Disinfection By-Products (6);
- Other Inorganic Chemicals (44);
- Organic Disinfection By-Product (26);
- Other Organic Compounds (36);
- Organic Indicators (7);
- Pesticides (57);
- Radiological Quality (6);
- Microbiological (17);
- Wastewater ‘Signature’ Compounds (4);
- Synthetic and Natural Hormones (4);
- Persistent Organic Pollutants (27); and
- Chemical Contaminants Lists (49).

The Panel is aware of similar SAMPs being in place at other IPR projects overseas and it is important that ACTEW taps into these locations to ensure that it has drawn up an appropriate list of compounds and that the frequency of sampling complies, as a minimum, with the requirements of the ADWGs (NHMRC, 2004).

The Panel has reviewed a document provided by Ecowise (2007) that has outlined a Baseline Monitoring Programme that is based on the format from other locations as well as the requirements of the ADWG (NHMRC, 2004). It notes that this Programme is proposed for use during the pilot plant trials as well and that it will serve well as the basis for identifying the extent of the parameters to be monitored in the programme that will be required for the full-scale WPP.

It is stressed that any sampling and monitoring programme must be viewed as a ‘living document’ in that it is not unusual for the number of analytes as well as the frequency of sampling and analysis to change with time. Extensive coverage of analytes and frequent sampling at the outset will both reduce over time.

f. Independent Auditing

i. ACT Health

It is important that ACT Health, as the Health Regulator, carry out regular oversight of the overall scheme, as this is an essential component of effective risk management and protection of public health.

Outcomes of these assessment audits should be communicated to the scheme operators when available, together with recommendations for any corrective actions or improvement in scheme management.

ii. Environment Protection Authority (EPA)

It is important that the EPA, as the Environmental Regulator, carry out regular oversight of the overall scheme, as this is an essential component of effective risk management and protection of the environment.

Outcomes of these assessment audits should be communicated to the scheme operators when available, together with recommendations for any corrective actions or improvement in scheme management.

iii. Independent Audit Team

Periodic auditing of all aspects of the Recycled Water Management Plan is a necessity to ensure that all activities are being carried out according to defined requirements and are producing the required outcomes.

The audits are in addition to any oversight by ACT Health and the EPA and can be both ‘internal’ and ‘external’ in audit team make-up with the frequency of, and schedule for such audits, being clearly defined. For example, the NEWater Programme in Singapore is audited by an Internal Audit Panel every 3-4 months and by an External Audit Panel every 6 months, with the findings of both Panels being presented to management and operational personnel as well as to the CEO and Chairman of the Public Utilities Board – the owners of the initiative.

6. Monitoring Overall System Performance

The Panel has recommended in Section 4a that there be one integrated HACCP Plan for the entire water supply system and that this covers the following items:

- Trade waste control;
- Sewer network;
- LMWQCC;
- WPP;
- Transport to the wetlands;
- Wetlands;
- Cotter Reservoir;
- Mt Stromlo WTP; and
- Water distribution network.

The Recycled Water Management Plan will be an adjunct to his Plan and will include both the operational and verification monitoring required to ensure that the *Water2WATER* project functions as intended.

At present, there are individual monitoring programmes in place at LMWQCC, Cotter Reservoir and Mt Stromlo WTP and it will be necessary to combine these with those included in the Recycled Water Management Plan to produce a system wide Monitoring Programme that can be used to gauge the overall system performance

It is likely, given the source of the purified water that will be introduced to Cotter Reservoir, that the existing monitoring programmes at LMWQCC, Cotter and Mt Stromlo WTP will require adjustment, much as is suggested by Ecowise (2007) in its report to ACTEW.

This document suggests that there be a concerted sampling and monitoring programme implemented on:

- Inlet to LMWQCC;
- Discharge from LMWQCC;
- Cotter Reservoir;
- Inlet to Mt Stromlo WTP;
- Discharge from UV at Mt Stromlo WTP; and
- Water reticulation system.

This programme will cover a wide range of analytes and will serve as the basis for the future system wide monitoring programme and The Panel supports this initiative, as it will lead to a meaningful programme for future use.

7. Monitoring health impacts

The Panel is aware of Health Effects testing that has been carried out at various of the overseas IPR plants as a means of monitoring the potential for long-term or chronic health impacts of introducing purified recycled water into a community's water supply, which showed no adverse impacts (Law, 2003; Kahn & Roser, 2007). Section 5b details the results of these studies in its discussion on types of health risk.

Nevertheless, it is important that there be an on-going health monitoring program in place to assure the public at large that, if implemented, the *Water2WATER* project does not become one of 'out of sight, out of mind'. The Panel understands that the following monitoring programs are in pace in the ACT:

Infectious diseases:

Notifiable infectious diseases are reported to the Communicable Diseases Network, Australia (CDNA). The Panel notes, however, that it is often difficult to establish epidemiological proof of waterborne transmission of viral diseases as the symptoms may not resemble those of typical waterborne bacterial and protozoan diseases, and many of the infected persons will show no symptoms. Some viral infections, such as hepatitis A, are difficult to trace to a source because of the long incubation periods (several months). Further, drinking-water is often only one of various possible routes of transmission, and adequately sensitive methods for detecting the infectious agent in water are often not available.

Birth outcomes:

Routine, statutory, notification to AIHW National Perinatal Statistics Unit, UNSW

Other toxicity:

Acute: Ad hoc surveillance via General Practice network and Canberra hospitals system

Chronic: Much less easy to detect because of variable duration of subclinical phase ("latency").

This latter category also includes any risks of cancer from waterborne carcinogens. Cancer is an obligatory registrable disease, and cancer incidence data can be monitored over time for the ACT – and (for comparison over space) for adjoining regions of NSW

8. Community Views

This component of the report is concerned with community views of the *Water2WATER* proposal received by the Panel. Although the Panel has concerned itself only with health issues, many in the community responded to the proposal in a holistic manner, addressing a broad range of issues concurrently including environmental, economic, planning and social issues.

a. Community Consultation Strategy

ACTEW's Consultation Program was conducted from Thursday 22 March and until Friday 22 June 2007. The Panel received submissions until Monday 11 June. The Consultation Strategy had three components aiming to inform, educate and engage the ACT community on the proposal to introduce IPR to Canberra.

ACTEW provided a comprehensive range of mechanisms to disseminate information on the project and to provide the community with an opportunity to make comment on the proposal. These are summarised in Table 11. The table shows the level of response received from the community during the consultation period. The consultants engaged by ACTEW (Manidis Roberts), will be providing a comprehensive report of the consultation process by the end of June

Table 11: Community Consultation Methods and Community Responses

Summary Community Responses (11 June, 2007)	**Numbers**
Detailed Submissions to The Panel (Health Specific)	2
Brief email submissions to the Panel and ACTEW (Health Specific only 53)	176
Letters (ACTEW + The Panel)	9
Phone (*Water2WATER* project office)	102
Telephone Survey	350
Information kits distributed	506
ACTEW Information Displays: Community views expressed verbally	1501
Events Information: Views expressed via feedback form	263
Community Forums (ACT 29 and 30 May, Queanbeyan, 14 June)	141
Community Briefings (attendance)	799
Media monitors (63 print articles, 278 broadcast summaries) Reported 16.04.07	180
ACTEW Water2Water website hits	4429

A brief summary of community views on health issues, gained through the various consultation mechanisms are summarised below.

b. Detailed Submissions

Detailed written submissions were received by the Panel from:

- Engineers Australia; and
- Professor Peter Collignon.

These two submissions are at Appendix B

The consultation process was seen more as a marketing exercise than as an opportunity to consider how best to make use of Canberra's water resources by using more recycled water or a genuine consideration of alternatives.

For *example*

> *"Engineers Australia in principle strongly supports making greater use of recycled water, including for potable purposes. But, Engineers Australia has reservations about the present proposal because the 'consultations' process is more a marketing exercise selling the merits of the proposal than about genuine consideration of how to make the best use of Canberra's water resources by using more recycled water. At present there is qualified support in the community for the use of recycled water. The closer the application is to human contact the less support there is. Over time these reservations can be addressed using information and education techniques which explain the issues and aim to overcome emotive and entrenched attitudes. However, PR techniques are not an answer".*
>
> *"*Engineers Australia argue for moving expeditiously on securing Canberra's water source however the case should be substantiated as to why the Cotter Reservoir is preferred and why other alternatives are inappropriate. "*Options should be ranked according to cost-benefit analyses which take into account broader community perspectives including considerations that are not directly the responsibility of the water provider*".

The submission suggests that the *Water2WATER* proposal is lacking in sufficient risk assessment and management information and proposes, "*the public production of a risk management assessment and risk management plan should be made available prior to the project being agreed*".

The submission also addressed a range of issues in relation to the inclusion of options for using recycled water and the need to review the ACT approach to environmental flows.

Professor Peter Collignon is an Infectious Diseases Physician and Microbiologist and Professor, School of Clinical Medicine, Australian National University. Professor Collignon's submission addresses a broad range of issues however this discussion will report only on those views expressed relating directly to The Panel's terms of reference.

The submission raises concerns about:

> *"… putting the recycled water* ***directly*** *into the small Cotter Reservoir (3.8 GL), instead of into artificial wetlands (which don't look to be able to work very well in the Canberra proposal anyway). This will mean that the sewage recycling proposal is then really a "direct" potable recycling scheme. Because the recycled water will be placed into a very small capacity dam, this water will also only have very short retention times and be subjected to only relatively small dilution effects. Also there will be no slow exposure via shallow marshes, wetlands etc, where UV light and other factors might have a protective and "polishing effect" on any viruses or other pathogens that might be in the water if a mishap with the equipment occurred."*

In relation to the safety of the treatment technologies the submission acknowledges that the equipment and membranes that will be involved with the current proposal (eg filtration, reverse osmosis, etc) are technologically very advanced systems providing that they work. Professor Collignon raises concerns about the capacity of reverse osmosis to remove salts and nitrates from treated water (about 1 to 2% of salts and between 10 to 50% of nitrates are not removed and only about 92% of antibiotics are removed from treated water (i.e. only about a one log reduction). He also expressed concern about the very limited data available on how well reverse osmosis removes viruses.

The submission raises the issue of the adequacy of testing procedures for the detection of micro-organisms.

> *"If we use recycled water or water from other sources (Murrumbidgee River, Googong Dam) then these are all much higher risk water sources. Thus there will need to be substantial increases in both the frequency and types of testing being done. There will need to be additional testing for enterococcus, bacteriophages, spores of C. perfringens and if feasible enteroviruses, norovirus and rotavirus…Spores of C. perfringens are very hardy and also largely of faecal origin. Thus if C. perfringens is present it is an indicator for viruses and parasitic protozoa that may also be present. Bacteriophages are viruses that infect bacteria and those that infect coliforms are known as coliphages, or more generally, phages. Phages have been proposed as microbial indicators as they behave more like the human enteric viruses which pose a health risk to water consumers if water has been contaminated with human faeces. Research results show that phages cannot be considered as reliable indicators, models or surrogates for enteric viruses in water. Enteric viruses have been detected in drinking water supplies despite tests that were negative for phages".*

Professor Collignon's primary argument is that "*recycling water from sewage into drinking water is a high risk procedure*" and that putting recycled water from sewage into drinking water should be a last resort.

c. Emails, Letters and Phone contacts

As part of the consultation program, ACTEW appointed a Community Liaison Officer who had primary responsibility to act as the project's first point of call for members of the public attempting to contact ACTEW. A total of 287 contacts were made to the project office. This consisted of 102 phone calls, 176 emails and 9 letters. ACTEW reported that feedback via phones and emails was more negative or concern-based. The main feedback received about the *Water2WATER* proposal by the project office were health related issues and the questions about the treatment processes to be employed to treat the water. Other common concerns include the legitimacy of the community consultation process, issues around environmental flow management, cost, and discussion around 'other supply options'.

Of the 176 emails to ACTEW 42 were directly related to health concerns. An additional 10 emails and a single letter were received directly by the Panel. All but one of these brief submissions expressed concerns about the *Water2Water* recycling proposal. Box 8indicates the range of health concerns expressed from the emails and letters received. Many people were not opposed to recycling water for non-potable use.

Some people expressed the view that the decision to go ahead had already been made and that the panel was simply a "*rubber stamp*" or that the Panel was biased. Some suggested that a microbiologist should have been on the Panel.

Box 8: Range of community concerns on health received from brief email submissions

I am yet to be convinced that the proposed plant can treat sewage to an adequate level"
As you know Trihalomethanes (THMs) are produced by chlorination of recycled water with sewage elements as the precursor…LMWQCC effluent is heavily chlorinated. Lower Cotter will offer far less dilution…self purification by river flow is unavailable, and hence THMs in lower Cotter are likely.
I approve of recycled water but can I be assured that hormones as well as other chemicals will be completely removed
I'm not sure if the proposed purification techniques will have any effect on removing chemicals, industry waste and other toxins…if we need to recycle water it should only be used as a last resort
One of my worries is that it will contribute to antibiotic drug resistance… There is a wide body of evidence that chemicals in combinations can produce a wide range of effects even at low concentrations, for example endocrine disruptions
If this sewerage to water program goes ahead, we will be moving to another state"
If the Govt. goes ahead with the Water2Water proposal it is taking risks with the public's health, since pharmaceuticals and viruses cannot be filtered out to 100%, dealing with them at 98-99% is not acceptable
I would like to protest in the strongest terms about the water recycling proposal. I totally disagree with using recycled effluent because no one has determined the consequences or can measure the effects of combination pesticides and pharmaceuticals that are flushed into the system, in particular female hormones, antibiotics and antineoplast drugs,… To compare us to Singapore is not a valid comparison because our climate is completely different and in cold temperatures bacteria does not break down to the same degree.
I have little confidence of filtration systems to detect and remove the variety of chemicals used in industry and households which may find there legitimate or unlawful way into the waste system including: heavy metals, isopropylamine salts, dimethylamine salts, dioxin, zinc pyrithione
I see this as a health risk especially for those with depressed immune systems, young children, babies
What will happen to check that the waste I generate after my chemotherapy has been made safe in the process of recycling water and ensuring it is safe to drink
I am concerned about human error and equipment failures…state what guarantee is being made in terms of water quality.

d. Community Forums

Three community forums were conducted in which 141 people participated:

- Woden (n= 65);
- Ainslie (n= 58); and
- Queanbeyan (n= 18).

The forums provided members of the public with the opportunity to receive information about the proposal from ACTEW, the Chair of The Panel and the Chair of the ACT inter-departmental Water Security Taskforce. Participants were then able to raise issues, comments or questions with the presenters, after which they worked in small groups to identify the most significant issues in relation to the proposal.

At each of the forums at least 90% of participants reported the forums were valuable and many reported having had their concerns addressed (Ainslie 41%; Woden 68%; Queanbeyan 38%). More people who had concerns about the proposal attended the forums than those who did not have concerns. At the Woden forum 94% said they had concerns about *Water2WATER* before the evening as compared to 79% at Ainslie and 77% in Queanbeyan.

Health issues, costs and alternative options to the *Water2WATER* proposal were the three issues of most concern. Table 12 shows the top 10 issues identified as concerns from each forum.

Table 12: Issues of concern raised at community forums

Woden	**Ainslie**	**Queanbeyan**
1. Not enough information to make informed decisions on all options.	1. Health issues (hormones, heavy metals)	1. Health concerns
2. Insufficient alternative investigations	2. Decisions to be based on long term planning.	2. Explore more options
3. Health – is it safe?	3. Reduce demand at household level	3. Demand management/efficiency
4. Need to supply an ongoing water supply	4. Wasted water reductions	4. Guarantee water for all
5. Transparency of costs	5. Conversation of the need for the Tennant Dam	5. Monitoring
6. Environmental impacts	6. Industry and Government conservation of water	6. Environment
7. Water conservation behaviour	7. Further investigation of short term options for supply security	
8. Mandatory sustainability measures	8. Justification and magnitude of environmental flows	
9. Better planning for climate change	9. Additional water storages	
10. High costs economic energy	10. Community Education Program	

e. Community Briefings

The aim of the community briefings was to make contact with a variety of stakeholders and community groups and to invite these groups to briefings on the proposal with the objective of gaining an understanding of the issues of these groups and explain the benefits of the *Water2WATER* proposal and the consequences of the failure to adopt sustainability water supply strategies. Table 11 shows that 799 people attended 31 community briefings. The briefings provided an effective means of communicating information on the proposal to a wide variety of stakeholders but did not collect formal feedback from participants about their views on the proposal throughout the consultation period.

f. Events and Information Display

ACTEW produced an Information Display that explained the *Water2WATER* proposal. It was complemented with water tastings of purified water from Singapore and feedback forms asking for comment on the display. This display was rotated around various Canberra locations. A total of 1501 community members verbally expressed views on the proposal of which 54.3% responded positively, 11.3% negatively, 34.4% indicated a neutral view. In addition 263 individuals provided written feedback forms of which 55.1% were positive, 24.3% were neutral and 20.2% were negative of the proposal.

ACTEW reported that comments received from the public at events and briefings were more positive than those received by phone, email or in submissions.

g. Project Website

ACTEW developed a project website provide the following content:

- Information on technical and health aspects;
- IPR around the world;
- Frequently asked questions (FAQ);
- Online survey;
- Virtual tour of the proposed project;
- Downloadable Information Kit;
- Related links;
- Overview of Expert Panel; and
- Information updates.

During the consultation the Panel received some feedback on the website including concerns about the limited nature of the information available in the early stages of the consultation, the location of information on the website, clarity of graphics or images and adequacy of the information. The Panel also queried some of the accuracy of the information on the website and forwarded these comments to the Community Consultation Working Group. ACTEW continued to update information on the site, in particular the section related to FAQ by the community and has included answers to questions raised at the community forums.

h. Advertising and Editorial

A series of press advertisements were produced to introduce the *Water2WATER* proposal to the community and to promote the schedule of community events and meetings. Full page advertisements were placed in the Canberra Times, The Chronicle and City News focusing on 'why put forward the *Water2WATER* proposal- and the current water situation'. Two further phases of advertisements were released on 'the options ACTEW has considered' and 'the treatment process proposed'. These advertisements were placed weekly. Television and radio advertisements encouraging residents to have a say were run in the month of June. An information brochure on the project was sent to all households. This brochure provided basic information on the proposal and community consultation process.

Mixed responses to the information released by ACTEW were reported by the community through letters to the editor and at community forums. Those who expressed dissatisfaction commented on the quality of information made available, inconsistencies in information and a lack of information discussing a range of alternative options to the *Water2Water* proposal.

i. Surveys

ACTEW engaged an independent market research company (ORIMA Research) to conduct surveys throughout the engagement process. These included:

- A random telephone survey halfway through the consultation process to determine the level of support and level of understanding of the water situation and the proposed project. This was conducted in the first week of May;
- An online survey (available on the Project website) that mimics the above survey but that is self-selected; and
- A hard copy survey as above for distribution during face-to-face interactions.

The phone survey involved a representative cross section of 350 households across seven areas of Canberra. The phone interviews gathered information on a number of core questions and demographic information including age, gender and income. A more detailed breakdown of results will be presented in the final consultants report. The following results were reported in the ACT Omnibus Survey Summary Report produced by Orima Research for the ACTEW Corporation.

Based on the description provided to respondents about the *Water2WATER* project, 75% of respondents indicated that their initial reaction was either positive (53%) or conditionally positive (22%). While 10% had a neutral reaction, 15% had either a negative (19%) or conditionally negative reaction (5%). Respondents who indicated a positive but conditional reaction were primarily concerned about health issues and pointed out more needed to be done in terms of planning to address the water situation. Respondents who indicated a neutral reaction felt not enough information was provided and that they were concerned about health issues. Respondents who indicated a negative but conditional reaction generally had concerns about the health impact and the quality of the water.

More than a quarter of respondents indicated that either the health and safety of the treatment process must be of very high standards (29%) and/or the quality assurance of the process be strictly monitored (31%). Just over 20% indicated they had no reservation of the project. Thirteen percent felt that there is a need for more public awareness/ education programs.

No information was made available to the Panel on the analysis of other survey results (online and hard copy).

j. Media

The ACT Government engaged Media Monitors to undertake daily monitoring of media reports, talkback and letters. ACTEW reported that preliminary observations of responses to the proposal were that media coverage appeared mainly negative, with respondents requesting more detailed answers and assurances that purified water is safe to drink. Other questions about alternatives to recycling, Tennant dam, Tantangara Dam, reducing environmental flows and reducing demand rather than addressing supply were raised. Towards the end of the consultation period Media coverage was less frequent but the discussion still focused on other water supply options and aspects of the treatment process.

Media Monitors presented a mid-way analysis of coverage of ACTEW and the water recycling proposal, between January 30 to April 16 and identified 278 radio and television broadcast summaries and 63 press articles. A final media analysis report is expected at the end of June.

News articles, opinion pieces and editorial comments were predominantly neutral or favourable. However, of the 28 letters-to-the-editor published in the Canberra Times a large proportion of these were un-favourable towards the proposal. Most articles analysed over the period focusing on the recycling process included issues such as microfiltration, *Water2WATER*, public consultation and the Cotter Dam. The majority of articles were either favourable or neutral.

Public health was the second most prominent focus of press and broadcast coverage in the first half of the consultation period. This included discussion of contaminants in recycled water, guidelines and research into public health issues related to recycled water. The majority of press articles were favourable. Alternatives to *Water2WATER* and cost were the other leading issues of coverage. This coverage also involved discussion of cost analyses of alternatives to water recycling and the construction of new dams and increased use of grey water.

k. Organised Community opposition

A group identified as ‘Water Our Garden City Inc’ mobilised to organise a campaign against the *Water2WATER* proposal through lobbying members of the ACT legislative assembly and the general public. They organised a public forum and distributed information to the public arguing that the proposal was un-necessary, high in energy consumption, expensive and unsafe.

> *“So why should we pay $350 million plus for the privilege of drinking recycled sewage? Must we be the guinea pigs for sewage water recycling technology that is still developing, risky, expensive, virtually unused anywhere else and just not needed here? Email, ring, fax or write your Legislative Assembly member NOW (GPO Box 1020 Canberra ACT 2060). Tell them that you want a clean, safe, constant water supply at reasonable cost and without the high costs and risks of recycled sewage”.*

l. Conclusions: Community views

Overall only a small proportion of the Canberra and Queanbeyan communities actively participated in the community consultation process despite having a broad range of mechanisms in place by which to become involved and make comment on the *Water2WATER* proposal.

Community views that were gained by random contact with the community through events and surveys tended to be more positive or neutral to the Water2Water proposal. Those who self selected to submit their views through letters, phone contact, emails or detailed submissions tended to express more negative views and concerns about the proposal. On the basis of the available information, it is reasonable to conclude that the majority of the community are not greatly concerned with the *Water2WATER* proposal on the basis that a larger proportion of the community would have become involved in the consultation to express opposition. The low level participation could reflect::

- Broad acceptance of the proposal or a lack of significant concern;
- Lack of motivation to respond; or
- Insufficient time to engage in the consultation process.

For those who actively engaged in the consultation by submitting their views formally a small proportion of the community voiced strong opposition and raised significant concerns about health and safety issues in relation to the proposal. Although the numbers are small the issues raised are serious and have warranted careful consideration by the Panel. In summary the range of health issues raised by the community included concerns about:

- Residual contaminants in the purified water;
- The effectiveness of the water purification technologies and the proposed treatment train;
- The health effects of contaminants in purified water;
- Regulatory requirements and water quality monitoring;
- Risk assessment and risk management plans;
- Levels of risk to the public;
- Risks for people with special health needs; and
- The limits of long term studies of health effects.

In addition the community has clearly communicated a desire for a more detailed investigation of other options for securing Canberra’s water supply to be considered.

It is generally accepted that meaningful community consultation processes require adequate time, resources and planning. Most best practice guidelines for community engagement recognise that the timing of any engagement activity is crucial to its success and recommended that the absolute minimum for any community engagement activity be six weeks. For large projects, policies and strategies seeking comprehensive feedback, twelve weeks is recommended. Although 12 weeks was allocated to the *Water2WATER* consultation, this is a short timeframe in comparison to other similar consultations on water recycling and the consultation may have benefited from a longer period of time due to the complexity of the issues and volume of information required by the community for effective decision-making.

In addition, the quality of material distributed to the public requires careful consideration and review before it is posted to websites or used in mail-outs.

The draft AGWR (NRMMC and EPHC, 2007) emphasise the importance of community support for the introduction of drinking water augmentation schemes. These guidelines highlight that the community has to be regarded as partners in the development of such schemes and that community consultation and communication needs to be maintained through the life of schemes. Information provision and transfer needs to be transparent and it is essential that trust is established and maintained. All sectors of the community and stakeholders need to be considered.

In accordance with these guidelines the Panel recommends that an ongoing community engagement process take place if the *Water2Water* proposal is adopted. This would allow for more detailed information to be made available to the community and to begin developing mechanisms for a longer term collaborative engagement approach in which the community can become partners in decision-making processes. Opportunities for collaborations should be identified with partnership organisations, including health, environment and natural resource management agencies, industry associations, other recycled water suppliers, university departments, other research organisations and community groups. Community consultation and engagement should be incorporated into and inform all stages of future water security initiatives including the planning, design, implementation and management stages of specific projects. This would encourage a system of water stewardship that places a priority on partnerships between the community and water authorities.

At present there is qualified support within the community for the use of non-potable and potable recycled water however significant concerns have been raised about health and safety issues of the current *Water2WATER* proposal. These require sufficient time and resources to be addressed. The community recognises the need to act expeditiously in securing a water supply but express a desire to investigate a wider range of options for securing sustainable water for the future.

9. Recommendations to Chief Minister

The Panel considers that a reverse osmosis-based water purification plant is feasible as a method of increasing the water supply for Canberra, subject to stringent health and safety requirements being met as set out in the AGWR (NRMMC and EPHC, 2007) and the approval of ACT Health as the regulatory body responsible.

The Panel notes that various natural barriers, large dilution effects, long retention times in reservoirs and long circulation times in shallow water where UV light and other processes can help “polish” water, provide protection against pathogenic micro-organisms that might be present in our water catchment area. To protect the population of Canberra against exposure to waterborne infectious agents, it is important that these natural barriers are part of the total recycling system. The same general argument applies to other potential chemical, pharmacological and other non-microbial contaminants in the recycled water.

The Panel recommends that:

1. ACTEW only proceed to continue investigation into a dual membrane Water Purification Plant (WPP) and that the alternative treatment train using ozone and biologically activated carbon not be considered further, due to the salt, nutrient and organic carbon loads entering the drinking water supply if this method of treatment were to be used;

2. The lower Cotter Reservoir be enlarged and the Panel notes the intention to construct this simultaneously with the water purification plant and ancillaries;

3. An extensive monitoring program be undertaken at the Lower Molonglo Water Quality Control Centre (LMWQCC) on the influent (water entering the system) and effluent (water leaving the system) concentrations of microorganisms and contaminants of concern prior to detailed design of the purification plant;

4. ACTEW provide a Recycled Water Management Plan that includes the following information before the process is commissioned:
    - The staffing levels proposed for the new plant;
    - The level of training that the plant operators will have undergone prior to plant commissioning;
    - The means by which the operation of each of the stages of treatment in the WPP is monitored and maintained at the optimum level (e.g. where relevant, details of membrane integrity testing, specialised on-line instruments etc);
    - An approved Hazard Analysis and Critical Control Point (HACCP) Plan that shows the likely Critical Control Points (CCPs) for the various stages and barriers in the WPP, together with ‘action’ and ‘shutdown’ values; and
    - An integrated Drinking Water HACCP plan that incorporates the Plans for the LMWQCC, the WPP and for the regulation and control of trade wastes that enter the sewer;

5. The WPP be staffed for 24 hours/day for at least the first 5 years of its life;

6. ACTEW carry out a modelling exercise to investigate the impact of the nutrient loading in the purified water on the water quality in the enlarged Cotter Reservoir;

7. An ongoing community engagement process take place if the *Water2WATER* proposal is adopted. This would allow for more detailed information to be made available to the community and to begin developing mechanisms for a longer term collaborative engagement approach in which the community can become partners in decision-making processes; and

8. Community consultation and engagement be incorporated into and inform all stages of future water security initiatives including the planning, design, implementation and management stages of specific projects. This would encourage a system of water stewardship that places a priority on partnerships between the community and water authorities.

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Acknowledgements: The panel wish to acknowledge the excellent work of Meagan Morrison and Tony Blattman from ACT Health in compiling this report, the willing support received from Lee Rupil and the encouragement of Dr. Maxine Cooper throughout.

Appendix A: Terms of Reference for Expert Panel on Health

As of 22 March 2007

Background:
The proposed *Water2WATER* project involves purification of water released from the Lower Molonglo Water Quality Control Centre to at least the standard of our existing drinking water. It is proposed that the purified water would be pumped to the Cotter River catchment, pass through a wetland, mix with the waters in the Cotter River and be stored within Cotter reservoir. Water from the Cotter reservoir including the added purified water would be pumped to Mount Stromlo Water Treatment Plant for treatment and distribution.

The ACT Government has commissioned ACTEW to undertake and report on a community consultation process seeking community views on the proposal.

Purpose:
The Chief Minister is establishing an independent Panel of Experts to report on and provide advice on the suitability of the proposed water production (purification) facility from health perspectives.

Panel of Experts Scope of works:
The initial work by the panel will be to produce an information paper on the health issues related to the proposed project, to facilitate community understanding and inform public discussion.

The Panel will review, analyse and report on:

- The capability of the combination of proposed treatment systems to remove all contaminants to the levels specified in the Australian Drinking Water Guidelines;
- Any residual health risks that may exist from using the purified water for drinking and ways of removing any such risks; and
- Community views of the proposal.

The Panel will also be required to:

- Identify any additional work necessary to complete the assessment and improve the feasibility of the project;
- Provide expert opinion on key issues and progress in addressing those issues;
- Advise on procedures to manage risks arising from any potential non-compliance with water purification procedures;
- Examine the scope of the proposal in the context of other state and international purified drinking water initiatives; and
- Report on the outcomes from the community consultation program.

Panel Expertise:
The Panel is to consist of experts of international standing in the following fields:

- Toxicology;
- Microbiology and water-related epidemiology;
- Public Health; and
- Community Information.

Timeframe/workload:
It is anticipated that the Panel will complete the investigation and report within three months.

ACTEW will provide administration support to the Panel, and a Government representative will participate in Expert Panel meetings as an observer to bring issues requiring action back to the Working Group.

Appendix B: Submissions Received

1. Submission from Professor Peter Collignon

June 7th 2007

Recycling water from sewage into drinking water: a "high level" health risk we do not need to take in Canberra

Professor Peter Collignon
Infectious Diseases Physician and Microbiologist
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Declaration of interest statement

I do not have any contracts, consultancy arrangement or research grants from any companies that may derive major financial gains from building sewage recycling plants (eg engineering companies such as CH2M Hill, Veolia Water etc) nor from institutions that may be involved with the large sums of monies that will be needed to finance these types of projects (eg Macquarie Bank, Babcock and Brown, and/or water infrastructure funds).

I declare that I have previously owned a small parcel of shares in AGL (which is in a business partnership with ACTEW and thus derives profits from water supply and use in the ACT in conjunction with ACTEW and the ACT Government).

In making this submission I am expressing my own opinions on a matter of the very important public interest and concern as a medical and public health expert in the field of microbiology and infectious disease. I am not making any adverse imputations on the possible motives of any party who may be seeking to promote the recycling of treated sewage into water for human use as drinking water. The statements made herein represent my own considered opinions and judgements and do not necessarily represent those of any employer of mine or of any other institution with which I may be, or may have been, affiliated.

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Submission

i. Introduction

One of the major advances in Public Health over the last 150 years has been to keep micro-organisms that are commonly found in the faeces of people and animals, out of our drinking water supplies. We are protected by treating drinking water (with chlorination, flocculation, etc) but also and just as important, in the protection of our catchment areas by minimising the entry of human and other waste (both treated and untreated).

Protecting the catchment is important because no disinfectant or sterilising system works instantaneously. They all rely on time to kill micro-organisms. Thus the more micro-organisms present in the water initially, the longer it takes to kill them. If there are large numbers of organisms present, then there is a bigger risk that all these micro-organisms may not be eradicated before the water is consumed by people.

The problem with proposals to recycle sewage into our drinking water supply is that this is a fundamental reversal of one of the basic principles that have helped keep our drinking water safe (i.e. keeping sewage out of our catchment area).

ii. Membranes and reverse osmosis do not remove all drugs and salts

The equipment and membranes that will be involved with the current proposal (eg filtration, reverse osmosis, etc) are technologically very advanced systems. Providing that they work, they should be effective in protecting us from the large numbers of disease-caused by micro-organisms present in sewage including viruses (although data is sparse).

Despite what is frequently claimed or implied by those promoting this technology for the recycling of sewage into drinking water, reverse osmosis (RO) does not remove all salts and nitrates from treated water (about 1 to 2% of salts and between 10 to 50% of nitrates are not removed). In Brisbane, reverse osmosis appeared to only remove about 92% of antibiotics from treated water derived from sewage (ie only about a one log reduction).

There is only very limited data available on how well reverse osmosis removes viruses, when used on large volumes of sewage. Direct testing for viruses is rarely or infrequently done, because of cost and technological problems. Thus other markers are used to assess performance (eg pressure, conductance changes etc) which are in effect used as "surrogate" markers to assess virus and pathogen removal from water. However if we used salts or nitrates as surrogate markers for virus removal, then we would obviously be far from happy with the performance of RO to remove viruses. Some pilot studies and some operational tests from Singapore suggest that all viruses are removed by RO. However the data remains very limited (eg only about 20 tests for enterovirus appear to have been documented in the Singapore expert report).

Even if a system does remove all viruses when it is working normally, there always remains a risk, that something may go wrong on occasion (as is the case with any complicated engineering system). We need to remember that there have been numerous recent outbreaks of water-borne infections in the US, Canada and Europe that have resulted from both human failure and equipment failure involving much simpler water treatment processes (chlorination, filtration, flocculation, etc). This recycling process is an addition to any water system and hence an added risk.

I can only agree with the comments made in the recently released environmental discussion paper by the eWater Cooperative Research Centre; "No treatment system anywhere in the world can be guaranteed to be absolutely failsafe 100% of the time. Consequently, equally important to the treatment system chosen must be the provisions made for detecting failure and ensuring that there is no break-through or leakage of incompletely treated water or wastes."

I note that contrary to what has been in ACTEW's very extensive advertisement campaign and what I and most people in Canberra have been led to believe, the incorporation of a reverse osmosis step may not occur, as it is only one of the options being examined. This point was noted in both the recently released health and environment discussion papers. Given that RO is one of the few technologies available that will effectively remove most drugs and appears to be the best available technology currently to remove very small pathogens such as viruses, I find it very disconcerting that ACTEW is even contemplating that RO might not be included. I think it is has also been very misleading of ACTEW and others not to make this point clear in their public statements and advertisements.

It is important to also note that in other countries where water from sewage has been recycled, that in general all sewage from industrial areas, hospitals, abattoirs, pathology laboratories etc are excluded from the recycling schemes. This is because of fears that there may be larger quantities of unknown chemicals or other toxins in sewage from these types of sources in comparison to standard domestic sewage from residential areas. There concerns are based on worries that not all the toxins, chemicals etc from industrial areas may be removed by the sewage recycling processes and also that these chemicals may be more likely to damage the membranes using in reverse osmosis. Thus there is a perceived risk that sewage from these areas may increase the chance of a malfunction in the recycling process because of membrane failures. We have less industry in Canberra compared to most other large cities in Australia. However our industries etc still contribute a large proportion of sewage. If we then recycle all the sewage from Canberra from the Molonglo outflow, as is currently planned, we will be participating in a scheme that will thus incorporate this type of industrial waste-water and which has not been done any where else in the world. We thus have no where else from which we judge efficacy and safety performance.

iii. This is a "High Risk" proposal and there will be inadequate natural safety barriers in place if something goes wrong

If we do a Risk Assessment, this proposal is "high" risk, if one assesses it by the criteria set out in the risk matrix table from the Australian Drinking Water Guidelines (2004) – indeed it is probably "very high" risk. The reason for this "high" risk rating is that even though it should be rare that failures would occur with the system, the consequence of a failure, if it occurs in a large city such as Canberra, is that tens of thousands of people, or more, could potentially be exposed to pathogens.

If this current proposal was to proceed, nearly all of the natural safety barriers that should be in place as part of any standard Risk Management approach will have been removed. In the recently released draft environmental report, frequent comments are made on the implications of membrane and system failure (more so than in the draft health report).

In the environmental report, concerns are also raised re the large volumes of water that will be put upstream of the very small Cotter dam. Because of these reasonable environmental concerns, I note that there is a proposal to consider putting the recycled water **directly** into the small Cotter reservoir (3.8 GL), instead of into artificial wetlands (which don't look to be able to work very well in the Canberra proposal anyway). This will mean that the sewage recycling proposal is then really a "direct" potable recycling scheme. Because the recycled water will be placed into a very small capacity dam, this water will also only have very short retention times and be subjected to only relatively small dilution effects. Also there will be no slow exposure via shallow marshes, wetlands etc, where UV light and other factors might have a protective and "polishing effect" on any viruses or other pathogens that might be in the water if a mishap with the equipment occurred. To go ahead with this proposal without finding better ways to test to ensure firstly that micro-organisms such as viruses may have slipped through (eg from small membrane leaks etc) and then also remove as many natural safety barriers as possible, strikes me as leaving this as a "high risk" proposal but without now adequate natural safety nets in place (ie multiple natural barriers).

I note that in the recent Health and Safety issues paper similar concerns re the need for multiple safety barriers were raised. "The multiple barrier approach to water safety would be enhanced by an enlarged Cotter reservoir, with higher water residence time. This provides a safety element in the treatment sequence and an opportunity for natural pathogen reduction."

iv. Pumping recycled water from sewage into drinking water is rarely done elsewhere in the world

It is frequently stated in the media and by ACTEW that this is not a new proposal because everywhere else in the world sewage is frequently recycled into drinking water. I believe however, that those types of statements are very misleading. The main example usually given is Singapore. However the water recycled in Singapore from sewage is used almost entirely for industry. The recycled water is very good quality water with a low salt content and it is offered at discount price. Thus it is very much in demand by high volume industry users such as computer chip manufacturers. This recycled water is kept separated from their drinking water by the use of separate pipelines. In Singapore, only a token 1% (or less) of their potable water is recycled from sewage (which is put back into their drinking water supply reservoirs).

Most recent proposals for recycling water from sewage, emphasise all the "non drinking" water purposes that this water will be used for, and it appears that they keep this recycled water away from their potable supplies as much as possible (eg information supplied by the large multi-national engineering company CH2M Hill which is involved with the recycling plant in city of Oxnard in California). In most other areas of the world where water is recycled from sewage "indirectly" into potable water supplies, it is usually done by replenishing aquifers and often because of the previous over-extraction of this underground water which has then resulted in the risk that salt water would enter the aquifer (eg Orange County and Oxnard). When recycled water is put into aquifers, there are usually also very long retention times before any recycled water is used. This means the many natural processes we have to help protect us against pathogens can still operate (eg major dilutions of the added water and prolonged storage or retention times). These natural processes result in viruses, bacteria etc dying off with time – often a 10 fold reduction in numbers every few weeks. In addition if water flows slowly through natural and shallow wetlands, UV light and other factors will usually kill human pathogens, and thus this wetland process is also protective. These types of additional safety barriers however will not be present if something should go wrong in Canberra. The recycled water here is effectively going to be recycled directly into our water system (almost a world's first - except for Windhoek in Namibia).

It is not just my view that we are proposing to do something very radically different in Canberra. A recent article in the Financial Times from London points out that this system proposed for Canberra has really not been done anywhere else in the world.

This also means that few epidemiological studies that have been done elsewhere to access safety are unlikely to be very useful for accessing the safety of this proposal for Canberra. Windhoek is probably the only comparable example for what is proposed for Canberra and using a developing country in Africa for such analysis is problematic and not appropriate. There is thus a paucity of published data available that shows this proposal is safe.

I note this point is also made in the recently released Heath and public safety report, "there have been relatively few systematic epidemiological studies of long-term health outcomes in communities supplied with drinking water supplemented by purified water."

v. There are other safer uses for recycled water rather than using it as drinking water

I am not arguing against using recycling water from sewage. I do however believe that one of the last places we should put this recycled water is into the drinking water. We should use it for other purposes such as industry, power stations, irrigation, etc. It is only if we then still have problems with a deficiency of water for drinking and household use that we then should consider recycling it into our potable water supply. There are places in the world where there are few alternatives but to recycle this type of water into potable water supplies. In general those are areas that have very poor average annual rainfalls (300 mm a year or less) and/or problems that have resulted after they have extracted too much water from aquifers: sea water would otherwise enter it and therefore leave them without any drinking water or with very badly compromised drinking water (eg Orange Country). None of those situations however is applicable to Canberra.

It should be noted that we effectively use drinking water to keep Lake Burley Griffin full during droughts, as water is released from the Googong dam for that purpose. Surely it would be better if recycled water was used for this purpose and for irrigation of the parliamentary triangle, industry etc. Currently in Canberra large quantities of drinking water are used for that purpose. If we can substitute recycled water safely for these purposes, then there will be less water used from our dams, obviating the need to recycle sewage into our drinking water.

vi. A needless risk for the population; we have enough water in Canberra

In Canberra we generally, without water restrictions, take about 65 GL/year (on average) of water from our reservoirs (one GL is a billion litres). With Level 3 restrictions we take about 50 GL from storage in a year. In an average year, however more than 210 GL of water enters our dam storage system from rain. Even during the recent and ongoing record drought since 2001, despite relatively mild water restrictions, the Canberra community has managed to keep our dams at reasonable levels (more than 50% of capacity). The exception was the year 2006 when there was very low rainfall and there were only about 25 GL inflows into our storage. However at the beginning of 2006 (ie 5 years into the current prolonged drought) we still had storage levels at 68% of capacity. This had however dropped to about 35% by the end of 2006. We would only have serious problems if we have repeatedly, year on year, very low inflows. Such low inflows however would represent an over 80% reduction on our average inflows. Even in the worst case scenarios from CSIRO on climate change, there are only predictions of a possible 30% reduction in inflows over the long term. While such reductions would obviously be a problem, it would still mean that there would be more than enough water available to meet the needs for our community, as even a 30% reduction would mean on average that about 160 GL would still flow into our dams each year.

Water currently leaves our storage for purposes of domestic and industry consumption (about 50 GL per year with level 3 restrictions). We also lose about 10 GL a year through evaporation from storage and leakage. Our rivers also need to have water released from storage, with a minimum requirement of about 4 GL per year. This adds up to a total minimum requirement of about 64 GL per year of inflows into our dams with current usage patterns.

2006 was a very dry year with poor inflows into our dams. However despite this, in that year 17 GL was either released from or spilled over the dam wall of the Cotter and Googong dams (12.7 GL and 4.3 GL respectively), despite inflows of only 25 GL. (Releases from these two dams are the only water that is "lost" from our storage system.) In retrospect we also did not have enough domestic water restrictions in place earlier enough in 2006, despite the poor rainfall and inflow being evident half way through the year.

We need to learn from our mistakes in 2006. Dry years like 2006 are likely to occur again. In retrospect, we need to;

- decrease our domestic use of water earlier (by water restrictions); and
- better monitor and control the amount of water we released from these dams as river flows.

If we do this better in the future, we could save more than 20 GL a year. This is the equivalent volume (or more) of the amounts of water likely to be recycled from any sewage-recycling plan.

vii. This is a very high energy proposal – it is not green or environmentally friendly

It is also important to remember that the sewage recycling plant proposal using reverse osmosis is really the same as a desalination plant. It therefore requires large amounts of energy (approximately 6,000 kilowatt/hours of electricity per ML of water produced). In Canberra it is estimated that will produce an extra 57,000 tonnes of extra CO_2 per year from plant operations. The recycled water will also be pumped over 13 km and uphill (it involves a 260 metre lift, firstly to the lower Cotter catchment and then again up to the Stromlo treatment plant). This pumping requires substantially energy requirements (more than the processing itself). These figures come from the recently released "Preliminary investigation of environmental issues discussion paper" which also points out that to be carbon neutral the process will require an additional 300,000 trees per year to be planted. To expend this energy with all its associated greenhouse gas emissions when this is not necessary in Canberra seems a very poor choice. Not only is this a very costly monetary exercise, the associated ever ongoing high-energy consumption will be contributing to the very problem blamed for changing our climate in the first place!

There are also other environmental impacts arising from the necessity to get rid of wastewater (10% to 20% of water used) from the RO process itself and the high concentrations of brine, salts, microbes, drugs and other products this water will contain. The high concentration of pathogenic micro-organism in this water will require its own detailed risk assessment and risk management plans, especially for their safe disposal (and especially if transport of part of this material is planned).

There will also be significant effects on the local environment by the now much higher water flows when the recycled water is put into the small streams and creeks of the Cotter Dam catchment area. Indeed one of the recommendations from the environmental experts, because of these environmental impacts, is for the recycled water to be put straight into the Cotter Dam. That would however turn this proposal into a "direct" potable recycling option – something not done anywhere else in the world except for Windhoek in Namibia (where there have been frequent periods of plant malfunction).

viii. "Direct" recycling into our potable system

The other concern with the proposal in Canberra is that even in its present form it is very close to a "direct" recycling into our potable system, ie water recycled from sewage being put directly into our reservoir and then taken out as drinking water. In Windhoek where recycled water is placed into a small 2.5 GL dam, this is defined in the international literature as "direct" recycling into potable water. It is hard to see why Canberra, when water will be put into a small 3.8 Gl dam should be defined as anything different.

It is currently stated that the Canberra proposal is an "indirect" potable recycling scheme as it allows "natural" processes to be present as added safety barriers if something should go wrong with the system. The current proposal is to create some artificial terraced, wetlands in the upper areas of the catchment for our very small Cotter Dam. Water will however likely reach the dam within a few days. The current dam itself is only 3.8 GL in size. It also needs to be kept around 90% full so as not to endanger the breeding ground of some endangered fish. This however effectively means that water will need to be pumped out of the dam almost as fast as it comes in, otherwise the water will just simply spill over the top of the dam. The only way the water can be pumped out is through our Stromlo treatment works and thus directly into the reticulated water system of Canberra, ie the normal piping that goes to homes and suburbs, etc. This means that we have a very short period of time between the recycling process and the recycled water being present in our reticulated water system. Given that it is planned that 20 GL of water per year will eventually be produced by this plant, and that during level 3 water restrictions we use only about 50 GL, potentially 40% of our drinking water will be from recycled sewage. It will also be used after a very short holding or retention time, thus bypassing a lot of the natural protective mechanisms that decrease micro-organisms with time. This means that if a misadventure should occur, we will have few "natural" protective mechanisms in place.

The planned artificial wetlands, if they have only 2 or 3 day retention times, are almost a token response to the need for natural barriers in place for added protection for people's health, as the retention times are far too short to be very effective. It will also be very likely that after heavy rain, these retention times will be negligible. Heavy rains are a well recognised risk factor for water borne infection outbreak when water is drawn from rivers etc.

ix. Procedures for testing micro-organisms are inadequate

In addition, the monitoring of this process will rely mainly on markers other than measuring micro-organisms to know whether the system may have malfunctioned (from an infection point of view this is know as using surrogate markers). There would be very little or no direct monitoring of most of the microbes that cause diseases if present in water. Total coliform counts are recognised currently as being among the poorest testing markers for faecal contamination and water safety. E.coli counts are superior, but still have major limitations. While E. coli counts will be measured as part of this new proposal, there is not likely to be much in the way of virus cultures or PCR etc, as the current technology for monitoring viruses that cause human disease (eg enterovirus) is expensive, slow, not yet standardised and not readily available. Unfortunately, while many faecal indicators are superior to *E. coli* and enterococci, these have not been developed to a point where there are methods readily available that are inexpensive and simple for routine use.

Currently and in the past, we have not done much microbiological testing in Canberra of water (predominantly colifoms, E.coli and testing for Giardia and cryptosporidiosis). This is because the main source of water for drinking in Canberra in most years is the two dams on the upper parts of the Cotter River (Corin and Bendora), which have pristine catchment areas. If we use recycled water or water from other sources (Murrumbidgee River, Googong Dam) then these are all much higher risk water sources. Thus there will need to be substantial increases in both the frequency and types of testing being done. There will need to be additional testing for enterococcus, bacteriophages, spores of *C. perfringens* and if feasible *enteroviruses, norovirus* and *rotavirus.*

Spores of *C. perfringens* are very hardy and also largely of faecal origin. Thus if *C. perfringens* is present it is an indicator for viruses and parasitic protozoa that may also be present. Bacteriophages are viruses that infect bacteria and those that infect coliforms are known as coliphages, or more generally, phages. Phages have been proposed as microbial indicators as they behave more like the human enteric viruses which pose a health risk to water consumers if water has been contaminated with human faeces. Research results show that phages cannot be considered as reliable indicators, models or surrogates for enteric viruses in water. Enteric viruses have been detected in drinking water supplies despite tests that were negative for phages.

x. Need to explore many other water saving options

There are many other ways we could save the amounts of water being planned by this sewage-recycling proposal. If we use water from the current Molonglo sewage outflows for non-drinking water purposes (such as for irrigation, keeping Lake Burley Griffin filled, industry, sewer mining etc), then instead of needing to extract 50 GL of water from our dams, we may well only need to extract 40 GL or even less per year. Water tanks on houses, better use of grey water etc will also decrease the amounts of water we need to draw from our dams. If we decide on other options rather than just the two that ACTEW has proposed, we will be recycling much more water in Canberra, but in ways that should have little consequence for human health if something went wrong. And then we will also be able to better save our pristine water particularly that in the Cotter catchment, for its best purpose, using it as a safe, inexpensive water supply for the population of Canberra.

xi. Risk management

Recycling water from sewage into drinking water is a “high risk” procedure because large numbers of people will be potentially exposed to a large variety of pathogens in the water, if the system malfunctions. The way to eliminate this risk is to avoid altogether recycling water from sewage into drinking water. As Canberra has many ways of obtaining or saving 20 GL of water – all safer and less expensive – this would seem to be the best option.

If however the sewage recycling into drinking water proposal was to go ahead, then the risk could be best minimised by only using the process at times of major shortages of water. Mr Michael Costello (Managing Director, ACTEW) in a letter he sent to me (see appendix) said “essential insurance which we hope … will seldom, if ever, have to call upon.” (see below)

> The balance of probability is that the extremely severe conditions of 2006 will not be repeated, and that there will be sufficient water to meet our needs without having to use recycled water. But what we have learned over the last few years is that for whatever reason we can no longer rely on the long-term averages. While it is unlikely, it is possible that we may face several more years in which river flows and inflows into our dams are at the extremely bad 2006 levels or worse. The consequences of this risk eventuating are so severe that even though it is a small risk we cannot afford not to take out insurance against it. And that is how we should see the recycled water project -- as essential insurance which we hope we will seldom, if ever, have to call upon.

I think his suggestion is a very sensible approach. If we proceed with the recycling plant then we can avoid exposing the population to any “risk” from recycled sewage being placed into drinking water if we don’t use the plant. It is likely that for the vast majority of the time we will have adequate water storage, and thus the recycling plant will not be operating, as is pointed out by Mr Costello himself. And I believe it is also likely to be the case once we have a larger storage capacity in place, such as the enlarged Cotter Dam. If we have a larger Cotter Dam and are wiser with how we use water from our dams, we should never find ourselves back in the situation of late 2006 and early 2007 re low total water storage levels.

However I note that in both the draft health and environmental reports, this recycling facility is being planned for continuous use 24 hrs per day 7 days a week, irrespective of our water storage levels ands rainfall. This appears to be inconsistent with what Michael Costello has written previously and needs to be clarified, as this issue is very important in any strategy to minimise risks.

It is also important to note that in general any disinfectant and chemical sterilising agent works better at higher temperatures. Canberra has colder water than most other Australian cities. Therefore longer contact times will be needed to achieve the same level of removal of organisms (ie log reductions) as would be needed elsewhere. This is an added reason why it is very important to have organisms in concentrations as low as possible in any water that is being processed. Temperature has important implications for chlorination of water and other disinfection processes such as any planned UV therapy. I also note that lower temperatures mean the membranes do not work as well and at the very least need to be replaced more often. Given Canberra’s cold water temperatures compared to other areas of Australia and Singapore, California etc, this is a significant factor that needs to be considered.

If the sewage recycling proposal is to go ahead, then we need to have as many safety barriers in place as possible and many of these should be “natural”. This means having very large dilution effects and long retention times before the water is used for drinking. This can only be done if the recycled water is in large reservoirs (eg the enlarged Cotter Dam or the Googong Dam). If the Googong Dam is used it should not go to that Dam via the reticulated water system. It is also preferable if by some means the recycled water could move very slowly (weeks or months) to the storage facility through some type of slow moving and shallow water system (eg wetlands) so that natural processes including UV light from the sun, as well as other factors, could help remove any pathogens and drugs that may be present, especially if a mishap occurs in the recycling plant.

xii. Conclusion

There are many in the community who are greatly concerned that ACTEW's current proposal to recycle water from sewage into drinking water, does not have enough safeguards for our population, nor have other options for recycling water, that does not involve recycling into drinking water, been adequately investigated and followed with community consultation.

There are many natural safety barriers that protect us from pathogenic micro-organisms even if micro-organisms enter our water catchment area. Nearly all these natural barriers will be removed in this current proposal. These include large dilution effects, long retention times in reservoirs and long circulation times in shallow water where UV light and other processes can help "polish" water. All these measures result in substantial reductions in the numbers of any micro-organism including viruses, which are currently very difficult to test for and monitor in water. It would seem foolhardy to proceed without leaving most of these natural barriers in place.

I do not believe that we should proceed with any recycling option that involves putting this water into our drinking water supplies until there is a large capacity reservoir to receive the water. Water in the receiving reservoir should also be preferably be kept off-line until we have adequate chemical and microbiological test results back - including viruses, that show that the treated water is safe. These tests need to be done frequently and be reasonably extensive. I think they need to be done at least daily and at many locations. I believe that to make this proposal at least of reasonable safety standards compared to international practice, we need to have either an enlarged Cotter reservoir completed before we proceed or else further carefully investigate the proposal so that any recycled water is placed into the Googong Dam (but not via our reticulated water supply).

Recycling water from sewage into drinking water is a "high" risk procedure. In Canberra this is an additional risk that the population does not need be exposed to, as in the vast majority of times we can store and access "pristine" water for drinking purposes from the upper Cotter catchment area.

My belief remains that putting recycled water from sewage into drinking water should be one of the last options we should adopt to improve water security, as it is a retrograde step in terms of water quality, and potentially a retrograde step in terms of cost to the community. In Canberra however this is the first of the only two hastily and inadequately prepared options that that have been proposed by ACTEW. There are numerous other ways by which we could either save or find alternative sources for the proposed amount of water to be recycled into drinking water. Most are also safer, cheaper and more environmentally friendly. I thus cannot see why we should contemplate subjecting the population of Canberra and our many inter-State and international overseas visitors to this "high" health risk procedure.

Appendices to Prof Collignon's submission are available from the Panel's website at **www.expertpanelonhealth.canberra.net.au**

2. Submission from Engineers Australia

THE WATER2WATER PROPOSAL

Submission to the Expert Panel on Health

May 2007

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1: INTRODUCTION

***Engineers Australia* is the peak body for engineering practitioners in Australia representing all disciplines and branches of engineering. Membership is now approximately 75,000 Australia wide and *Engineers Australia* is the largest and most diverse engineering association in Australia. All *Engineers Australia* members are bound by a common commitment to promote engineering and to facilitate its practice for the common good. *Engineers Australia* is organised by Colleges and geographic regions. This Submission is a joint undertaking between the Canberra Division of Engineers Australia and the organisation as a whole.**

Canberra's water supply situation requires the development of new ways to augment water supplies and to manage water demand. The Water2Water proposal, now the subject of your Panel's review of associated health issues, is but one of many approaches that are possible. Although in the past Canberra's water authorities have considered broad ranging reviews of water options, this was not the practice on this occasion. The approach this time has been to put forward a specific proposal without offering alternatives or indeed specific evidence why this proposal should be preferred. *Engineers Australia* believes that a component of the present proposal, to enlarge Canberra's water storage infrastructure, was adequately encompassed in the earlier reviews and so, at a general level, it is quite reasonable to bring it forward now. There are, however, alternative approaches and the particular choice of building a new dam on the site of the present Cotter Dam requires justification and this has not been provided.

Direct use of treated waste water for potable purposes has not been considered before. *Engineers Australia* in principle strongly supports making greater use of recycled water, including for potable purposes. But, *Engineers Australia* has reservations about the present proposal because the 'consultations' process is more a marketing exercise selling the merits of the proposal than about genuine consideration of how to make the best use of Canberra's water resources by using more recycled water. At present there is qualified support in the community for the use of recycled water. The closer the application is to human contact the less support there is. Over time these reservations can be addressed using information and education techniques which explain the issues and aim to overcome emotive and entrenched attitudes. However, PR techniques are not an answer.

To date no risk assessment information relating to the incorporation of treated waste water into potable water supplies has been released. There are two issues here. First, generally the community believes that outmoded absolute standards still apply and expect that water will be free of contaminants 100% of the time and are likely to be unsettled by the terminology commonly used in risk management being applied to water. The community requires the assurance that can only come from an open, transparent and availability risk assessment and risk management plans, accompanied by frank and open articulation of the issues. Second, at a technical level, using recycled water for potable purposes introduces an entirely new element to Canberra`s water supplies, one not covered by

any risk management process undertaken in support of conventional water supplies. If a risk assessment has not yet been undertaken, the proposal should not proceed until this is done.

There is a serious risk that the approach being used in Canberra will damage the long term prospects of moving to a sensible multi-pass model for water consumption and management. Repeating the Toowoomba experience will not resolve Canberra`s water crisis. The present proposal is inconsistent with research into community attitudes towards the use of recycled water for direct potable consumption and appears to depend on persuading the community that technology is the answer at a time when instinctive and emotive rationales are highlighted by research.

Other uses of recycled water are, however, strongly supported by the community. Options in this direction have been dismissed as too expensive without substantiating arguments. Community health in water policy is much broader than simply removing contaminants from recycled water and extends to water security so that outdoor activities from gardening to organized sports, which are all relevant to physical health, can continue. The ACT has had some success in using recycled water to maintain ovals and other sporting facilities and extending these arrangements deserves more serious consideration based on community bounded cost-benefit analyses. In the event that community based cost benefit valuations place a higher premium on water security than cost benefit analysis based on the views of the water provider, these differences should be addressed by Government.

2: NATIONAL GUIDELINES ON WATER QUALITY

***Engineers Australia* notes that the Panel "expects ACTEW to have Hazard Analysis and Critical Control Point (HACCP) accreditation for both the new purification plant and the existing LMWQCC."[i] Engineers Australia strongly endorses the application of the Drinking Water Guidelines[ii] for this purpose because the range of contaminants covered by this document is more relevant than the alternative, the Australian Guidelines for Water Recycling: Managing Health and Environmental Risks[iii] which, at a technical level, could also be applied. Besides providing the highest standard of scientific and engineering reassurance to the community, there are several aspects of both sets of guidelines which should receive further consideration.**

Both guidelines are major departures from procedures incorporated in earlier versions of drinking water and water recycling guidelines. Earlier approaches sought to set absolute standards against which levels of specific contamination could be gauged through on-going water sampling and testing. The set standards purported to differentiate between acceptable conditions from non-acceptable ones. The type of absolute judgments conveyed by this approach still predominates in community attitudes on these matters.

There are many reasons why the earlier approaches were abandoned, mainly the long list of possible contaminants presented real practical impediments to implementation, and the desire to move towards national

consistency. Both current sets of guidelines now use generic risk management frameworks which depend on the development of application specific detailed risk assessments and risk management plans.

***Engineers Australia* notes that the Recycling Guidelines indicate that the generic nature of the risk management approach is suitable for applications not specifically canvassed in objectives set out in that document. One of the examples of such an application that was cited was the use of recycled water to augment drinking water supplies[iv]. The suggestion here is that either set of guidelines will do, and at a technical level *Engineers Australia* would agree. However, there are important issues relating to public confidence at stake here which will be explored in the following Section. Using the National Drinking Water Guidelines will assist in shoring up community confidence provided, of course, that the difference in approach between risk management and setting absolute standards is understood and accepted by the community.**

Risk management techniques are familiar to many people, particularly to those in business community. However, the application of risk management techniques to water quality assessments is relatively new in the water industry and may come as a surprise to many in the community at large. The notion that water quality is "relatively safe" may convey the wrong impression to community members unfamiliar with risk techniques, especially when applied to concepts like water quality where many people believe that more absolute standards apply. This is not an argument against using risk management techniques; rather it is an argument for comprehensive and transparent information and education of the community about the approach being used and why it is acceptable.

At this stage the Water2Water proposal provides little information about what is proposed. This is unfortunate and somewhat short-sighted as the discussion in the following Section will show. Direct potable use of recycled water is seen as controversial in the water industry and the few attempts to go down this route in Australia have met with strenuous community opposition. There are no guarantees that this experience will not be repeated in Canberra. Providing factual information up front and in a transparent manner is a critical step towards success and this should be done as soon as possible. *Engineers Australia* is firmly of the view that the information provided to date does not meet this criterion.

It is vital that a comprehensive and transparent risk assessment and risk management plan is undertaken for the proposal to directly add recycled water to the ACT`s water supplies. The water source proposed is fundamentally different to conventional water sources used in the ACT and *Engineers Australia* believes that it is inappropriate to apply risk assessments that have been undertaken for conventional water sources to this new proposal. Assertions that the technology proposed is top class and can technically produce desirable results are not good enough. The risk factors for particular events, whether they are the existence of particular contaminants, operational errors or equipment breakdowns may be small, but community reassurance will only be won by demonstrating that the corresponding consequences are also small and demonstrating

that contingency plans are available to deal with them. *Engineers Australia* believes that it should be mandatory for the water provider to make available to the public the risk assessment and risk management plans, in language readily understood by the community, as a pre-condition for the proposal going ahead.

3: CSIRO RESEARCH ON ATTITUDES TO USING RECYCLED WATER

The appropriate guidelines may be the National Drinking Water Guidelines, but the water source proposed is treated waste water and so many of the issues raised in the National Recycled Water Guidelines remain relevant. So too does research into community attitudes about using recycled water such as recent CSIRO research[v]. This comprehensive three year investigation used well established survey techniques and behavioural methodologies to examine peoples` attitudes to using recycled water in different ways. The research was particularly detailed in its examination of the characteristics of recycled water uses and peoples` perceptions of them.

The research was undertaken in Perth and, following telephone selection of a randomly selected sample, began with a telephone survey. Survey 1 in Table 1 reports the acceptability of different uses of wastewater from this telephone survey. Participants were then invited to CSIRO premises and asked to taste test 15 samples of recycled water from different sources and vegetable produce irrigated by recycled water from different sources. This was followed by the administration of a second questionnaire which repeated the questions from Survey 1 as well as posing a range of new questions about participants prior experience with recycled water, awareness of Perth`s water issues, preferred terms to describe recycled water and the potential influence of cost on their acceptance or rejection of recycled water. Survey 2 in Table 1 compares responses on the acceptability of different uses of recycled wastewater after participants had completed the taste test. For the purposes of this Submission it is sufficient to focus on the results in Table 1, but the Panel may wish to acquaint themselves with the wider results directly from the study.

The responses in Table 1 are summaries of a 5-point scale with highly acceptable and acceptable on one side of the medium and unacceptable and highly unacceptable on the other side. The results of Survey 1 are consistent with previous findings that the acceptability of using recycled waste water decreased the closer the use moves to human contact. Applications like irrigating public parks, toilet flushing, watering playgrounds, home gardens and golf courses were all found to be acceptable or highly acceptable by over 90% of respondents. These proportions fell rapidly as the questions probed showering, filling swimming pools and cooking with recycled water. Finally, only 31.5% of respondents found drinking recycled water to be acceptable or highly acceptable. For this use the proportion of respondents who found drinking water unacceptable or highly unacceptable exceeded the proportion who found drinking recycled water acceptable or highly acceptable by a substantial margin.

TABLE 1

SUMMARY OF CSIRO RESEARCH INTO THE ACCEPTABILITY OF DIFFERENT USES OF TREATED WASTEWATER

USES OF TREATED WASTEWATER	SURV EY 1		SURV EY 2	
	Acceptable (%)	Unacceptable (%)	Acceptable (%)	Unacceptable (%)
Watering public parks	97.8	1.1	95.7	4.3
Home toilet flushing	98.9	1.1	93.5	3.3
Watering public playgrounds	95.7	1.1	87.0	8.7
Watering home lawns & gardens	95.6	2.2	89.2	6.5
Watering golf courses	96.7	2.2	95.6	4.3
Irrigating dairy pastures	84.8	6.5	82.7	13.0
Irrigating fruit & vegetables	88.0	8.7	67.4	26.1
Washing your clothes	78.5	12.0	72.8	19.6
Showering & bathing at home	57.6	27.2	53.3	33.7
Filling public swimming pools	52.1	27.2	47.8	35.9
Cooking at home	43.5	30.4	33.0	46.2
Drinking	31.5	45.7	23.1	57.1

Source: M Po et al,p11

Intuitively one might expect that exposure to the use of recycled water would convince people about its merits and safety. Survey 2 , however, shows that the opposite occurred. The broad ranking of acceptability in Survey 2 was very similar to Survey 1, but the acceptability of using recycled water was generally lower and the results about the unacceptability of drinking recycled water and other close human contact uses harden considerably. Indeed only 23.1% found drinking recycled water acceptable or highly acceptable, one third less than in Survey 1, and 57.1% found drinking recycled water unacceptable or highly unacceptable, one quarter more than in Survey 1. In this instance a substantial majority of respondents found drinking recycled water unacceptable.

Robust and modern technology is the essential starting point from which proposals for direct potable use of recycled water can be developed. However, technology is not necessarily pivotal to the acceptability, in the eyes of consumers, of recycled water. The CSIRO research lends weight to similar views articulated in the National Recycled Water Guidelines which emphasis that community attitudes to recycled water are more likely to be instinctive and emotional responses rather than responses to the technology proposed.

The risk that *Engineers Australia* sees is that the failure to adequately consult the community about using recycled water, as compared to selling a particular proposal, may impede developments towards greater use of recycled water. The National Recycled Water Guidelines also point out that the credibility of the organisation providing water recycling also significantly affects community perceptions. *Engineers Australia* strongly supports increased use of recycled water but is concerned that the approach being used in Canberra is not taking the issues outlined in this Section seriously.

4: OTHER OPTIONS FOR USING RECYCLED WATER

In 2004 the ACT Government announced its intention to increase effluent reuse to 20% by 2013[vi]. Paradoxically, the maximum proportion of waste water recycled in the ACT was achieved in the same year and it has since

fallen to 7.9% in 2005[vii] and to 6.7% in 2006[viii]. Recycling occurs in the North Canberra Water Reuse Scheme which is based on recycling treated effluent from the Fyshwick treatment plant to ovals and playing fields from ADFA, Campbell, Reid, O'Connor, Majura and the ANU. Sewer mining occurs at Southwell Park in North Canberra and finally there is some limited recycling of the treated effluent from the Lower Molonglo Water Treatment Plant. The Southwell Park sewer mining operation was recognized by being awarded an Engineers Australia Excellence Award in 1996. However, in 2006 recycled water substituted only 3.8% of the town water supply and contrary to popular perceptions, over 84% was for commercial and industrial applications[ix]. This suggests that the potential for using recycled water to irrigate public parks and playing fields has not yet been realized.

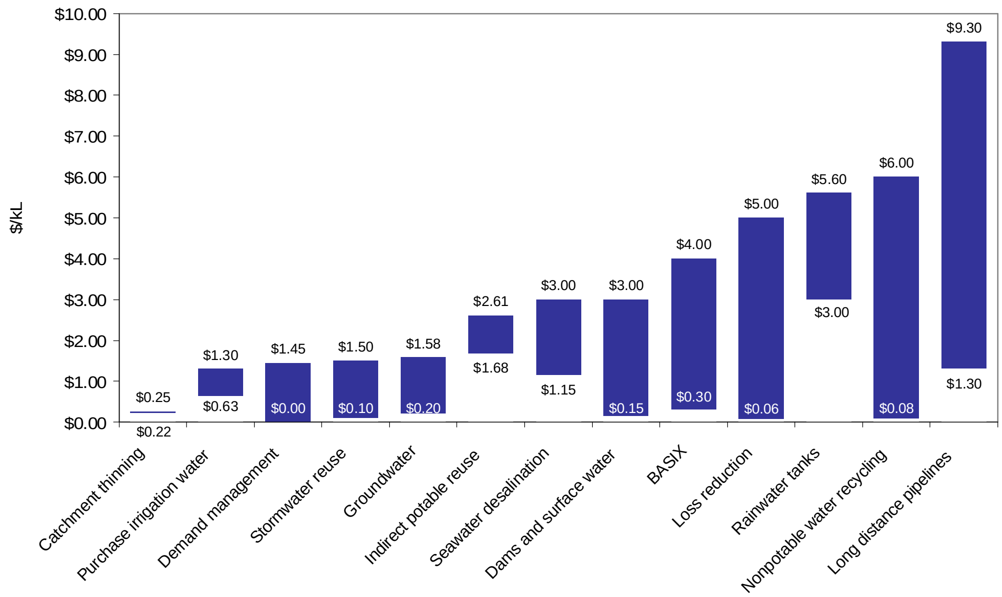
The ACTEW web site[x] advertises the CRANOS® system which it developed, and which received the Australian National Banksia Environmental Award for Technical Excellence in 1997, Engineers Australia`s Canberra Division Engineering Excellence Award in 1997 and the Australian Water and Wastewater Association Peter Hughes Award in 1998. CRANOS® is a small scale wastewater treatment plant suitable for treating the effluent from 1,500 to 30,000 people and is suitable for localized water recycling applications. The advantage of CRANOS® and the sewer mining techniques used at Southwell Park is the elimination of the costs associated with the transmission of treated water from the main treatment facility at Lower Molonglo and the containment of distribution costs to the recycling applications within the immediate vicinity[xi]. Yet the CRANOS® system has not been used in the ACT and there have been no further applications of the sewer mining system.

The Water2Water[xii] web site dismisses alternatives other than the recycling option proposed on the grounds that they are too expensive. There is no detail to substantiate these claims and this is a matter of significant concern in itself. Many comparisons of the costs of different options begin from data like that illustrated in Figure 1[xiii]. In this illustration option costs are expressed as cost ranges because site specific considerations need to be taken into account and some situations are more or less favorable to some options compared to others. Sophisticated water providers are aware of these estimates and would have locally relevant calculations which narrow down cost ranges.

Cost comparisons, however, only begin with these data. Specific options need to be subjected to cost-benefit analyses before final decisions can legitimately be taken. The appropriate question is 'too expensive relative to what'? Cost-benefit analyses may, of course, be undertaken from several perspectives. First, from the perspective of the water provider, in which case the boundaries for the cost-benefit study would be the obligations conferred on Directors and Executives by Corporations Law. Second, from the perspective of the ACT Government, in which case the boundaries of the cost-benefit study would be broader and take into account Government policies and political perspectives. Third, from the perspective of the ACT community, in which case the boundaries of the cost-benefit study would be wider still and take into account both

government and other perspectives and the views of the community as a whole and of specific groups that may be affected. *Engineers Australia* believes that given that secure water supplies are essential to the functioning of a modern city and community, cost-benefit analyses of alternative water supply options should be based on community views and values and not solely on the values of the water provider. Divergences between the two perspectives are important, and must be addressed by Government.

FIGURE 1: RELATIVE WATER SUPPLY OPTION PRICES CALCULATED FOR A RANGE OF AUSTRALIAN CAPITAL CITIES ($AUD/ kL)



Source: Marsden Jacob Associates, p24.

The substance of the Panel`s terms of reference focus on health considerations of the Water2Water proposal. Health in this context is not simply about the removal of possible contaminants from recycled water and *Engineers Australia* believes that the review should not be restricted to this view. It also includes health impacts from not watering ovals and playing fields which are key facilities for sport and recreation for people of all ages. It is also about gardening as a recreational pursuit. The costs of health impacts due to reduced participation in physical activity because facilities have become dangerous and the costs of remediating damaged playing fields are as relevant from a holistic perspective as the difference in capital cost between one alternative water technology and another. Similarly, the benefits of recreation and physical activity need to be balanced against financial costs of new infrastructure.

The North Canberra Water Reuse Scheme and Sewer Mining at Southwell Park have demonstrated that even in times of severe drought the playing fields within these arrangements can continue to be irrigated and remain in use. This evidence indicates that before the extension of these arrangements are totally dismissed the community should be informed about the details of cost benefit analyses that were undertaken and from

what perspective to justify the decisions and proposals made. This has not yet been done and selling the Water2Water proposal to the community is a poor substitute.

The Water2Watewer proposal is about using recycled treated wastewater to extend water supplies. But using recycled water is a much broader concept and includes recycling stormwater and grey water. Included in the former is the use of rainwater tanks. Once again, these options have been dismissed as too expensive without supporting evidence. While the rainwater tank rebate is a useful and positive initiative, other approaches have been ignored. Tank installation is impeded by a "first cost" barrier; as many people do not proceed because they cannot afford the up-front cost of tank installation. The rebate may be welcome but since it follows installation it does not overcome the barrier confronting people. An alternative would be to provide a loan scheme under which repayments become part of the water and sewerage bill. Funds presently spent on rebates could be redirected to pay for the administration of the scheme and to provide a measure of support for disadvantaged people. Recycling stormwater does not rate a mention in ACTEW`s proposal.

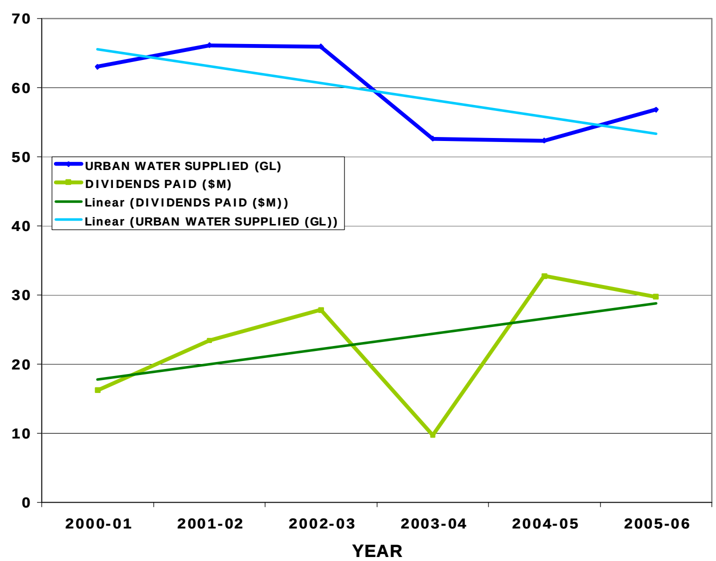
Water utilities generally argue that the community supports the imposition of water restrictions. As Allen Consulting[xiv] recently noted "The Australian community has been sold the concept that water is a scarce and finite resource." This has distracted from the main debate which should be about how to meet the demand for water in a sustainable manner. In reality there are numerous options available to increase the supply of water, albeit at higher costs. There are fundamental structural problems in the present approaches to water supplies, including[xv]:

- **Failure to treat water as a commodity similar to other life essentials such as electricity. Pricing is typically based on the costs of existing infrastructure and operational costs and often results in prices which are below the unit costs of sourcing new water and results in underinvestment in water infrastructure and disregard for the willingness of consumers to pay for greater water security.**
- **The costs of water restrictions are high. For the water provider they include the costs of administering and enforcing the restrictions and for water users they include:**
    - **Time and inconvenience costs.**
    - **Household investment in alternative high cost sources to keep gardens alive.**
    - **Reduced amenity values from private gardens and civic landscapes.**
    - **Foregone recreation values due to damaged and unserviceable playing fields, and subsequent restoration costs for playing fields following the end of drought.**
    - **Direct costs to businesses that depend on water availability and indirect cost on businesses because consumers reduce their demand for water dependent items, for example, garden centres.**

These costs are essentially ignored in cost benefit analyses of water supply options as discussed above. These costs are very high and need to be considered. The cost of water restrictions to Canberran households has been estimated to be between $198 and $769 per year depending on the severity and frequency of restrictions[xvi]. This equates to $20m to $77m for Canberra as a whole. The costs to Canberra businesses were estimated to be between $3.4m and $4.5m again depending on the severity and frequency of restrictions. This study estimated that Stage 3 water restrictions would save about an average 143kL in household water use. Allen Consulting[xvii] used the mid-point of the household cost range ($360 per household) to point out that this equates to a cost of $2.50 per kL which is higher than the costs of many other alternative sources of supply and indeed the cost of potable water supplied in Canberra.

Recourse to water restrictions is facilitated by regulatory arrangements which enable the water provider to partially recover revenue lost from lower water sales during restrictions by claiming 'pass through' costs in annual water price reviews. In contrast, water users are expected to shoulder the costs of water restrictions without compensation. This is essentially a subsidy for poor water planning which creates a bias in water planning towards greater recourse to water restrictions and so undermines normal market incentives to improve water supplies and water security. The evidence for this is found in Figure 2 which shows that water provider profitability, as measured by dividends paid, have continued to rise while urban water supplied has fallen.

FIGURE 2: WATER SUPPLIED AND DIVIDENDS PAID IN THE ACT



Source: NWC and WSAA, 2007, pp7 and11.

Water restrictions do not address the underlying issues which determine the demand for water. There are numerous documented examples of consumers reverting to normal behaviour when restrictions are lifted[xviii]. This line of though is supported by the CRC for Water Quality and Treatment[xix] which found that while drought raises the level of community consciousness about the importance of sustainable water use, community

attitudes about water use are firmly entrenched and require social attitudes to change before enduring outcomes are realised. Generalized conservation messages and moral suasion largely preach to the converted and fail to persuade key groups in society. For example, discretionary outdoor water use in Australia accounts for about 44% of household water use and even higher (55%) in Canberra. The CRC found that half the community maintains that it is their right to keep gardens green and healthy even though 88% believe individuals can make a difference. This is a clear signal that more creative solutions are needed.

5: INCREASING THE SIZE OF THE COTTER DAM

In 2003, a Report prepared by the Canberra Division of Engineers Australia argued that the ACT should expeditiously proceed to investigate, plan and design new water resource infrastructure[xx]. A regional approach was favored over more narrow ACT only considerations and one of the possible options raised for consideration was the enlargement of the Cotter Dam. At the time, the Canberra Division highlighted the availability of a number of options with similar sized additions to water supplies and which had similar costs. The Report argued strongly that there should be expeditious progress to providing a new water source for Canberra to ensure water security compatible with Canberra`s success as a National capital and a desirable place to live.

The Water2Water proposal is in essence about building a new dam on the site of the present Cotter Dam. No reasons have been presented why this option is favored over others except minimizing the costs of piping treated waste water to the Cotter Dam. In this respect, there is inter-dependence between the two components of Water2Water. This inter-dependence is not of itself sufficient to justify building a new Cotter Dam, especially in the light of other points made in this Submission.

***Engineers Australia* remains strongly in favour of moving expeditiously to provide a new water source for Canberra and accepts that the Cotter proposal will achieve this outcome. However, the case for choosing the Cotter over other alternatives has not been made available and it is imperative that this be done. *Engineers Australia* believes that additional water resource infrastructure is necessary whether or not the recycling component proceeds.**

A significant issue raised by the Canberra Division Report was the impact of environmental flows on the ACT`s water supplies, noting that water available for consumption would fall. The implications identified included significant direct financial costs for new infrastructure, the economic harm caused to some small businesses and the degradation of the garden city concept for Canberra through water restrictions and the costs associated with reduced availability of sporting fields.

***Engineers Australia* supports the way in which environmental flows have been included in the National Water Initiative as an equal partner in sharing available water resources. However, the protection envisaged for environmental flows does not extend to compensating for normal natural phenomena such as drought. If the ACT dams did not exist, drought would**

result in a normal diminution of river flows and nature has adapted to this pattern. The combined storage capacity of Canberra`s dams is 207 GL. In 2006 environmental flows released from dams (net of the flows released from the Lower Molonglo Treatment plant which were 29.0 GL) were 30.5 GL at a time when storages were at 50% of capacity due to severe drought conditions.

The Australian environment has coped with cyclical drought and floods for centuries. Environmental flows should be planned on the basis of sustainable extraction of water resources not on the basis that ACT water storages will provide flows in otherwise dry or lower rivers flows. Sustainable water management should work in harmony with nature. *Engineers Australia* believes that in the circumstances it is appropriate for the ACT to review its approach to environmental flows and how policy harmonises with natural weather cycles.

6: SUMMARY OF ENGINEERS AUSTRALIA`S VIEWS

***Engineers Australia* in principle strongly supports making greater use of recycled water, including for potable use. But *Engineers Australia* has reservations about the present proposal because the 'consultations' process is aimed at selling the merits of the option put forward rather than about genuine consideration of alternatives. At present there is qualified support within the community for the use of recycled water and further progress towards acceptance of recycled water for close human uses needs to be developed using information and education techniques rather than marketing of the Water2Water proposal. Support is high for using recycled water in a wide range of non-human applications, but the closer applications are to human use the lower the level of support, and indeed a majority is opposed.**

Furthermore, to date no risk assessment information has been released in line with National water quality guidelines. This assurance is vital given the relatively recent adoption of risk management techniques to water quality management and common perceptions that absolute standards apply to these matters. *Engineers Australia* believes public production of a risk management assessment and risk management plans should occur before the project is agreed.

***Engineers Australia* remains strongly in favour of moving expeditiously to provide a new water source for Canberra. However, the case must be substantiated as to why the Cotter should be preferred and why alternatives are inappropriate. *Engineers Australia* believes that additional water resource infrastructure is necessary whether or not the recycling component proceeds.**

Other alternatives to securing Canberra`s water supplies are also dismissed as too expensive without substantiation. Canberra frequently resorts to water restrictions and yet the costs of water restrictions to the community at large are ignored. Engineers Australia believes that full substantiation of water options selected and rejected must be openly and transparently provided. The basis of selection should be benefit cost analyses in which there is a full enumeration on community costs and

benefits. Benefit cost analyses limited to matters important to the water provider are inadequate.

***Engineers Australia* believes that it is appropriate for the ACT to review its approach to environmental flows in line with sustainable water extraction. Environmental flows are vital but policy should not attempt to compensate for normal climate cycles at the expense of water security. *Engineers Australia* is firmly of the view that water security for the ACT and region requires diversified demand and supply management with all options on the Table. Options should be ranked according to cost-benefit analyses which take into account broader community perspective including considerations that are not directly the responsibility of the water provider. In the event that community valuations diverge from valuations held by the water provider, this should be resolved by the ACT Government.**

ENDNOTES

[i] Expert Panel on Health, Health and Public Safety in Water Purification, An Issues Paper on the Water2Water Proposal, 25 May 2007, p2.
[ii] National Health and Medical Research Council and the Natural Resource Management Ministerial Council, Australian Drinking Water Guidelines, 2004 (Drinking Water Guidelines).
[iii] Natural Resource Management Ministerial Council, the Environment and Heritage Council and the Australian Health Ministers Conference, National Water Quality Management Strategy, Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase1), November 2006, (Recycled Water Guidelines).
[iv] Recycled Water Guidelines, op cit, p10.
[v] M Po, B E Nancarrow, Z Leviston, N B Porter, G J Syme and J D Kaercher, Predicting Community Behaviour in Relation to Wastewater Reuse, What Drives Decisions to Accept or Reject? CSIRO Water for a Healthy Country, May 2005.
[vi] ACT Government, Think Water, Act Water, April 2004, p4.
[vii] WSAA, WSAAfacts 2005, The Australian Urban Water Industry, 2006, p22.
[viii] National Water Commission (NWC) and WSAA, National Performance Report 2005-06, Major Urban Water Utilities, 2007, p9.
[ix] NWC and WSAA, op cit, p7.
[x] www.actewagl.com.au/wastewater/treatment/cranos.aspx
[xi] www.actewagl.com.au/wastewater
[xii] www.actew.com.au/water2water
[xiii] Marsden Jacob Associates, Securing Australia`s Urban Water Supplies, Opportunities and Impediments, November 2006, p24, www.dpmc.gov.au/waterreform
[xiv] Allen Consulting, Saying goodbye to permanent water restrictions in Australia`s cities, May 2007,p1.
[xv] Allen Consulting, op cit, pp2-4.
[xvi] Centre for International Economics, Economic benefit cost analysis of new water supply options for the ACT, Report for ACTEW, 2005.
[xvii] Allen Consulting, op cit, p4.
[xviii] See the discussion in Sydney Water Corporation, Water Conservation and Recycling Report, 2004-05.
[xix] CRC for Water Quality and Treatment, Community Views on Water Shortages and Conservation, Research Report 28, 18 November 2006.
[xx] Engineers Australia, ACT Division, Augmentation of Water Supply to the ACT and Region, Canberra, December 2003.