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Goulburn Mulwaree Council

Highlands Source Project Environmental Assessment

Drinking Water Quality

January 2010

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

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A Risk Assessment

Acronyms & Abbreviations

ADWG	*Australian Drinking Water Guidelines* (2004)
$CaCO_3$	Calcium carbonate
Cl_2	Chlorine (gas)
DAF	Dissolved air flotation
DBP	Disinfection by-product
DECC	Department of Environment and Climate Change (NSW)
DGR(s)	Director-General's Requirement(s)
DICL	Ductile iron cement-lined (pipe)
DoC	Department of Commerce (NSW)
DOC	Dissolved organic carbon
DoP	Department of Planning (NSW)
EP&A Act	*Environment Planning and Assessment Act 1979*.
FCR	Free chlorine residual
GMC	Goulburn Mulwaree Council
HACCP	Hazard Analysis Critical Control Point
HSP	Highlands Source Project
$KMnO_4$	Potassium permanganate
LGA	Local Government Area
NHMRC	National Health and Medical Research Council
NSW	New South Wales
PAC	Powder activated carbon
SCA	Sydney Catchment Authority
TDS	Total dissolved solids
THM	Trihalomethane
USEPA	United States Environment Protection Agency
WHO	World Health Organization
WSC	Wingecarribee Shire Council
WTP	Water treatment plant

Units of Measurement

d	Day
g	Gram
h	Hour
ha	Hectare
Hu	Hazen units
kL	Kilolitre
km	Kilometre
L	Litre
m	Metre
mg	Milligram
mL	Millilitre
ML	Megalitre
mm	Millimetre
MPN	Most probable number
NTU	Nephelometric Turbidity Unit
ppm	Parts per million

1. Introduction

1.1 Background

Goulburn has faced severe drought and water restrictions since 2002. Goulburn Mulwaree Council (GMC), in conjunction with a State Government Task Force, identified an Emergency Pipeline from Wingecarribee Reservoir to the Goulburn water supply system as the best means of overcoming the emergency and drought proofing Goulburn for the future (GMC & DoC, 2007). Subsequent rains in June 2007 removed the emergency aspect of the project; however the need for improved water security remains.

Since 2007, a range of options for securing Goulburn's water supply have been investigated. In December 2009, GMC has prepared an Integrated Water Cycle Management Strategy that outlines actions for improving long term water sustainability. Part of the strategy involves investigating the feasibility of a pipeline from the Wingecarribee Reservoir to supply water to Goulburn (now termed the Highlands Source Project) will be an integral part of this Strategy. Additionally, GMC has undertaken a Goulburn Water Supply Strategy Review, in which the Highlands Source Project was identified as the best solution for improving the city's water security.

1.2 Description of the Project

1.2.1 General

The Project is to construct and operate the water supply scheme that would transfer water from the Wingecarribee Reservoir to the Goulburn water treatment plant (WTP). The scheme comprises approximately 83 km of DN 300 mm to DN 375 mm diameter pipeline, a pump station at the Wingecarribee Reservoir, power and controls, a balance tank, and a telemetry system. The pipeline would be buried along its entire route. The pipeline would be either ductile iron cement-lined (DICL) or stainless steel pipeline.

If approved it is proposed to have the transfer scheme operational by June 2011. The Project's timeframe is set by the conditions governing the provision of government funding under the Australian Government Water Smart Australia Program.

Key construction activities would include:

- Trench excavations and placement of the pipeline;
- Constructing railway, road and river crossings;
- Constructing a pump station and controls at the Wingecarribee Reservoir site; and
- Constructing a balance tank at an appropriate location along the pipeline (subject to design requirement).

The Project is presently in the preliminary design phase. Two options are being considered for the transfer of water to the Goulburn water supply system. These are:

- Pumping raw water from the Wingecarribee Reservoir to a reservoir located at the Goulburn WTP, for treatment there prior to distribution; and

- Pumping treated water from the Wingecarribee WTP to connect directly to the Goulburn water distribution network.

Both of these options would be progressed until detailed design phase.

Other operational activities would include:

- Regular maintenance of the pumping station;
- Regular maintenance of the air valves and scour valves; and
- Less frequent maintenance of the pipeline (*e.g.* pigging to remove blockages, or repairing bursts as required).

1.2.2 Water transfer and supply options

The water transfers would be made by a pump station located at the Wingecarribee Reservoir. The pipeline would likely be designed to accommodate a flow of approximately 7.5 ML/d (over a 22 h period). Initially the pipeline would likely deliver *ca.* 5 ML/d. Approximate transfer times are outlined in Table 1.

For the raw water transfer option, the water would be delivered from the pipeline into an existing water balance tank upstream of the Goulburn WTP, prior to treatment there.

For the treated water transfer option, the water would be delivered from the pipeline into a proposed new covered balance reservoir at Governor's Hill in East Goulburn. The water would then be piped directly into the eastern zone of the Goulburn water reticulation system.

There are also two options in regard to the mode of operation of the water transfer pipeline:

- Continuous operation – where water from the Wingecarribee Reservoir would be delivered daily to Goulburn so as to contribute some set percentage of the overall daily water demand;
- Intermittent operation – where water from the Wingecarribee Reservoir would be pumped to the Goulburn water supply system only on occasions where the existing water supply resources were measured to be below some trigger level.

A schematic of the Wingecarribee and Goulburn water supply systems and the two water transfer options being considered as part of the Project is shown as Figure 1.

Table 1 Water transfer times

Pipeline diameter DN (mm)	Transfer rate (ML/d over 22 h)	Transfer time (h)
300	5.0	25.8
300	7.5	17.2
375	5.0	40.3
375	7.5	26.9

1.3 Objectives and purpose of this report

On 9 July 2007 the Minister for Planning declared the proposed Project to be one of regional planning significance, pursuant to Section 75B(1) of the *Environment Planning and Approvals Act 1973* (the EP&A Act), and ordered the Project to be declared as a project to which Part 3A of the EP&A Act applies. A requirement is that the Project proponent must undertake an Environmental Assessment of the Project.

The objective of this study was to assess generally the potential impacts of the operation of the Project on the quality of the drinking water that would be supplied to Goulburn (particularly in comparison to the historical water supply quality), in support of the Environmental Assessment.

1.4 Approach

The steps of the approach for this assessment, listed together with a description of where each step has been documented in this report, were to:

- *Understand the systems.* Develop an understanding of the raw and treated water quality characteristics of the Wingecarribee and Goulburn water supply systems. This involved -
  - Developing a description of the present water supply systems (from catchment-to-tap) for Goulburn and Wingecarribee (Section 3); and
  - Undertaking a targeted analysis of water quality data to observe trends in drinking water quality at each system (Section 4).
- *Identify and assess risks.* The various ways in which the Project may result in water with different quality characteristics being supplied to Goulburn residents and other users were identified. The risks associated with these impacts were examined by undertaking a water quality risk assessment to examine the likelihoods of the described impacts arising, the consequences that could be associated with them, and to identify possible mitigation strategies (Section 5).

  NB: The system understandings from the previous step, together with the description of the Project (Section 1.2) and the operational and maintenance activities that would be associated with it were the primary inputs for this phase.
- *Document management activities.* This involved using the results from the risk assessment phase to identify and prioritise actions that could be undertaken or considered to manage any changes in drinking water quality being supplied to Goulburn and the associated risks that may arise (Section 6).

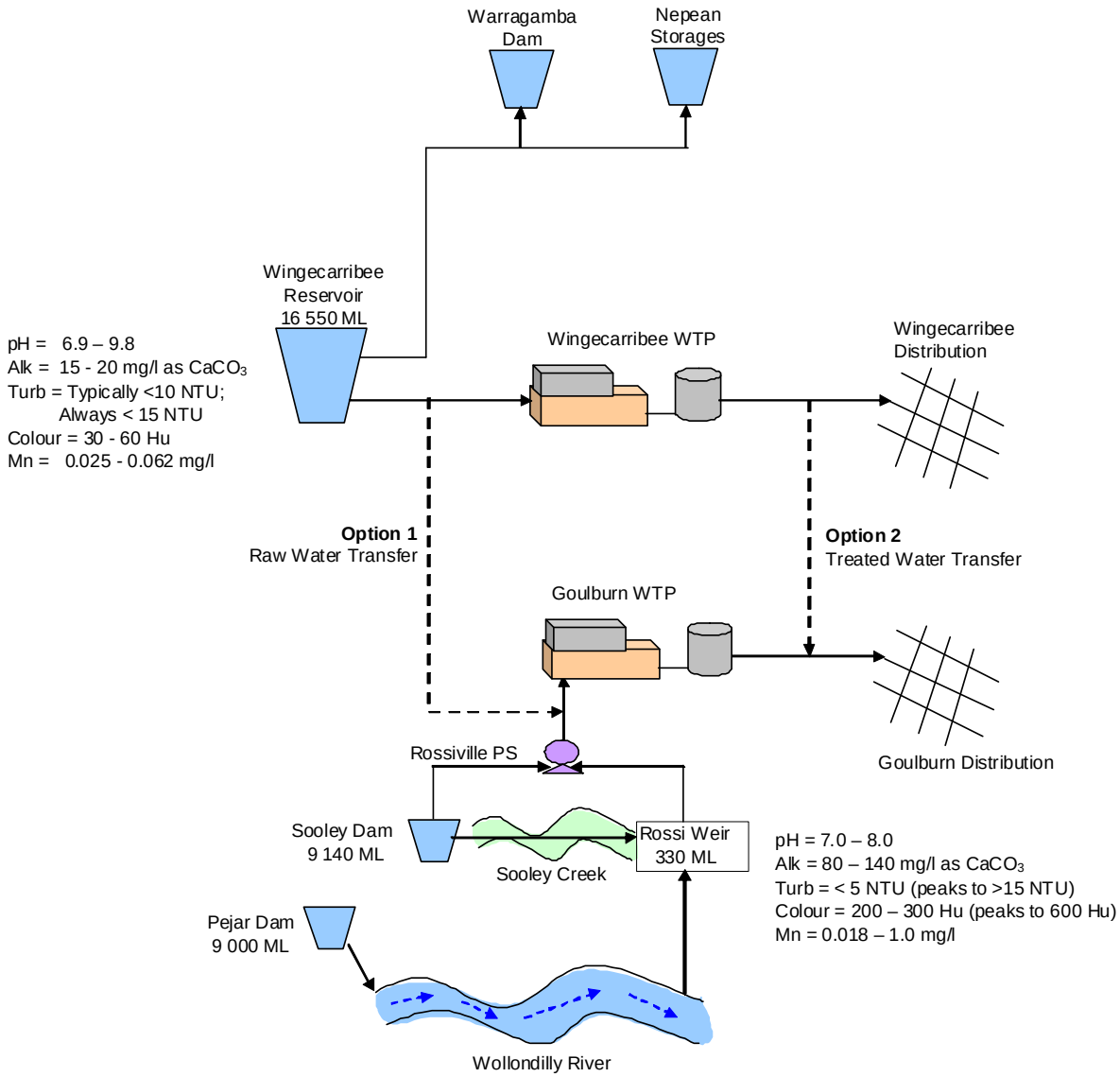

Figure 1 **The Goulburn and Wingecarribee water supply systems, and the options for transferring water being considered as part of the Project**

2. Legislation and Guidelines

This report section provides an overview of the legislation and guidelines relevant to drinking water quality and its management in NSW.

2.1 *Public Health Act 1991*

The New South Wales *Public Health Act 1991* makes reference to the safety of drinking water for human consumption. It is an offence, under Section 10IA, to "by means of a reticulated water supply system, supply any other person with drinking water that is not fit for human consumption."

The *Act* does not define safe drinking water, or stipulate any water quality requirements for the protection of public health. In NSW, water utilities are expected to satisfy themselves of the safety of the drinking water supply, including microbial, chemical, pesticide and radiological quality. However, Section 5 of the *Act* does provide a mechanism whereby if "[the Health] Minister considers, on reasonable grounds, that a situation has arisen under which the health of the public is, or is likely to be, at risk", then NSW Health has certain powers with respect to the provision of safe drinking water. These include powers to:

- require the issuing of advice to the public on the safety of a drinking water supply;
- require the correction of any misleading information issued to the public;
- enter and inspect premises of a supplier of drinking water;
- require testing of drinking water;
- require production of information including the results of testing; and
- order the rectification or closure of a water supply.

2.2 NSW Health and the *Australian Drinking Water Guidelines*

The NSW Government have endorsed the *Australian Drinking Water Guidelines*[1] (from hereon referred to as the *ADWG*), as a means of managing drinking water quality throughout NSW. The guidelines:

Outline a framework for assessing and managing drinking water quality. The following two principles are core components of the overall framework:

1. That the most effective way to manage drinking-water quality involves implementing a range of approaches and initiatives, including: physical water treatment; disinfection; catchment management (to prevent the entry of water quality contaminants at the source of the supply); and monitoring. This is referred to as a "multiple barriers" approach.
2. That a risk-based approach can be useful to assess both the system's water quality and how it can be managed. The approach should consider the water supply system from catchment-to-tap, together with an understanding of how water quality contaminants may enter and progress through the water supply and the risks associated with these contaminants and events.
3. Provide suggestions for suitable *health-based* and *aesthetic* criteria for drinking water quality for adoption throughout Australia.

[1] National Health and Medical Research Council (NHMRC), 2004. *Australian Drinking Water Guidelines*, NHMRC, Canberra

In all parts of NSW other than metropolitan Sydney, NSW Health implements a Drinking Water Monitoring Program (NSW Health, 2005). The program involves monitoring the quality of water from within the reticulation systems of towns and cities throughout the state. All monitoring results are recorded in the NSW Drinking Water Database. When monitoring results exceed an *Australian Drinking Water Guideline* value, the water utility is notified immediately.

Where a risk to public health is suspected based on NSW Health's routine monitoring for microbiological indicators and chemical contaminants, or health surveillance in the community, water utilities must follow up with repeat sampling and investigation. Where NSW Health considers that an unacceptable risk to public health may have arisen, the powers stipulated within the *Public Health Act 1991* may be enforced.

3. Existing Environment

3.1 Goulburn water supply system

GMC is the local government body responsible for provision of a water supply to Goulburn. Situated in the Southern Tablelands of New South Wales, GMC covers an area of 3 232 km^2 and is home to 27 277 people.

3.1.1 Goulburn's raw water supply

Goulburn's water supply is wholly sourced from a subcatchment of the Wollondilly River catchment. The catchment supports a variety of landuse, with agriculture (especially grazing) and semi-rural living being the main types.

There are three water storages that supply water to the town of Goulburn. These are:

- Pejar Dam (9 000 ML at capacity) on the Wollondilly River;
- Sooley Dam (4 140 ML) on the Bumana Creek; and
- Rossi Weir (330 ML) located further downstream on the Wollondilly River (GMC, 2009).

Normally, Goulburn WTP would be fed from Rossi Weir. The weir is filled from Sooley Dam via the Sooley Creek. However, the Goulburn WTP can be fed directly by Sooley Dam water via the Rossiville pump station. Rossi Weir can also be directly fed by the Wollondilly River and the Pejar Dam controls the river's headwaters. Water is transferred from Pejar Dam (to Rossi Weir) when Sooley Dam is unavailable, for example, due to low capacity or poor water quality. In summary, at any time Rossi Weir might hold a combination of water from the Wollondilly River catchment, water released from Pejar Dam or water from Sooley Dam (Hunter Water, 2003). Hence water quality can be variable and challenging to treat. Previous studies have indicated that Sooley Dam water can contain high counts of cyanobacteria and elevated concentrations of manganese (GMC & DoC, 2007; Hunter Water, 2003).

3.1.2 Goulburn water treatment plant

Goulburn WTP was constructed in 1948 and augmented in 1975 to its current design capacity of 32.5 ML/d (GMC, 2009). Engineering studies were undertaken in 1993 and 1995 and a powdered activated carbon (PAC) dosing unit was added to the process chain in 1999 to better manage blue-green algae risks.

In 2003, when drought conditions were placing severe stress on Goulburn's water supply, a further study was undertaken with a view to identifying changes at Goulburn WTP that would enable it to treat raw water of poorer and more variable quality (Hunter Water, 2003). The focus was on improving the robustness of Goulburn WTP to be able to handle:

- algal blooms (toxins);
- taste and odour compounds; and
- soluble manganese.

In 2005, a concept design study was undertaken for the installation of a UV disinfection unit. The aim was to provide Goulburn's water supply with an extra barrier of protection against intrusion from

pathogenic organisms (*e.g. Cryptosporidium*, *Giardia*) during emergency drought works (Hunter Water, 2005).

Goulburn WTP typically operates at 11 ML/d and employs the following treatment processes (Figure 2):

- potassium permanganate ($KMnO_4$) dosing;
- powdered activated carbon (PAC);
- pH adjustment (sulphuric acid dosing);
- coagulation / flocculation (dosing alum, flocculant aid, polymer);
- settling clarification;
- multi-media sand filtration;
- post-filtration pH correction (soda ash);
- ultra-violet (UV) disinfection;
- chlorination.

Treated water is then pumped to service reservoirs from where it is distributed to customers in Goulburn.

It has also been recommended that GMC should consider replacing the settling clarifier with a dissolved air flotation (DAF) clarification process (Hunter Water, 2005). This has not been implemented, but is till under consideration by GMC.

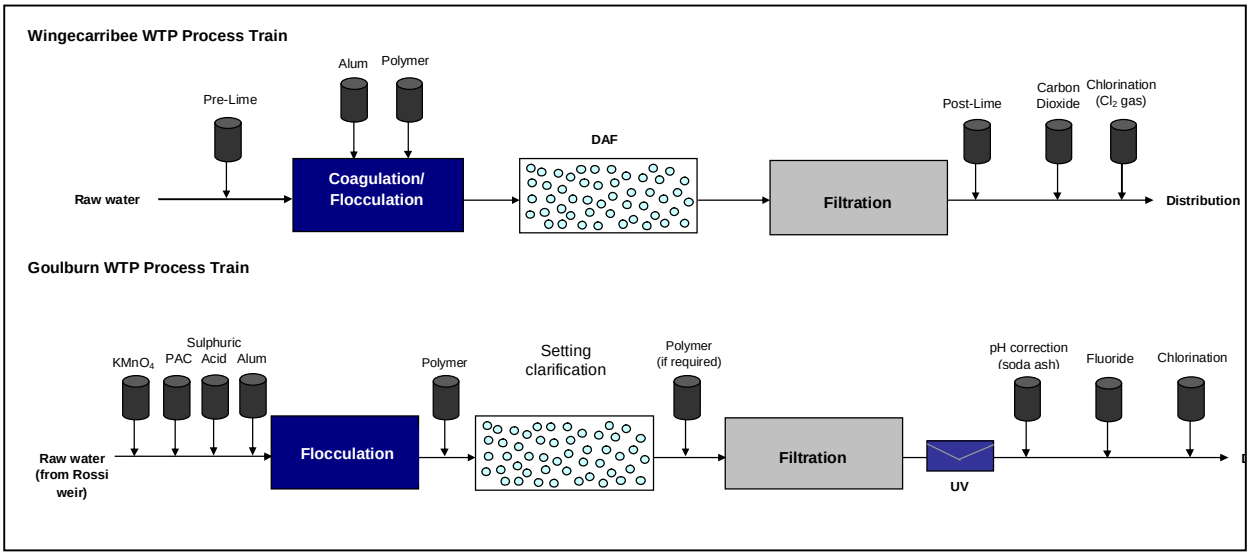

Figure 2 Goulburn and Wingecarribee WTP treatment processes

3.1.3 Goulburn raw water quality

A summary of Goulburn's current raw water quality is provided in Table 2. A detailed water quality data analysis is provided in Section 4. In summary:

- the raw water feeding into the Goulburn WTP is variable in turbidity and colour, which can probably be attributed to Goulburn's reliance on, and switching between, multiple raw water sources;

- the raw water pH is fairly stable. This stability in the observed pH levels of Goulburn's raw water is consistent with the relatively high alkalinity and hardness concentrations recorded (*i.e.* it is a well buffered water);
- total dissolved solids (TDS) concentrations are relatively high. Step changes in the raw water TDS concentrations can be significant (as depicted in the charts in Figure 13), presumably as operators switch between raw water sources;
- dissolved organic carbon (DOC) values are relatively high, which is also reflected in the measured true colour values that are typical in Goulburn's raw water;
- historically frequent detection and high measures of cyanobacterial counts in the raw water have resulted in GMC installing a powder activated carbon (PAC) dosing facility at Goulburn WTP to manage some of the risks posed by blue-green algae. GMC has also indicated that geosmin (a compound associated with the breakdown of blue-green algae, and that can cause unpleasant odours and tastes in water supplies) has posed a challenge in recent years (*pers. comm.* Marina Hollands, 28 November 2009);
- high levels of manganese in the raw water also has a history of challenging the WTP, however, this is now being managed by potassium permanganate dosing at the treatment plant.

Table 2 Raw water quality fed to Goulburn WTP

Water quality indicator	Raw water observations
Turbidity	Typically < 5 NTU but variable and peaks to > 15 NTU
E.coli	No data were available at the time of review
True colour	Usually 200 – 300 Hu, but frequent peaks up to 600 Hu
pH	Stable at values between 7.0 – 8.0
Alkalinity	80 – 140 mg/L as $CaCO_3$
Hardness	100 – 250 mg/L as $CaCO_3$
DOC	Typically 9 – 12 mg/L, concentrations have been measured at 18 mg/L
Cyanobacterial counts	Total cyanobacterial counts up to 940 000 cells/mL, though generally < 600 000 cells/mL; median *ca.* 10 000 cells/mL
TDS	100 – 500 mg/L, with pronounced step changes, presumably due to changes in source

3.1.4 Goulburn treated water quality

A detailed water quality data analysis is provided in Section 4. In summary:

- Goulburn WTP generally reduces true colour values down to < 10 Hu and turbidity values down to < 1 NTU;
- there is no removal of salts or reduction in hardness at Goulburn WTP;
- the measured pH values indicate that treated water is chemically stable (and well buffered);

- data on soluble manganese concentrations in treated water were not available for this study, however, potassium permanganate dosing is able to be undertaken at the WTP and so it is likely that manganese has been being reduced to levels in line with those recommended in the *ADWG.* NSW Health monitoring confirms this has been achieved in recent years;
- there were no data available for assessing the reduction in microbes achieved at Goulburn WTP; however, there are multiple barriers in place at Goulburn for pathogen removal (*i.e.* conventional treatment followed by chlorination and UV disinfection, see Section 3.3).

3.2 Wingecarribee water supply system

Wingecarribee Shire Council (WSC) is the local government body responsible for provision of a water supply to Wingecarribee. Situated in the Southern Highlands of New South Wales, the main towns in the shire are Bowral, Moss Vale, Mittagong and Bundanoon. The WSC covers an area of 2 700 km^2 and has a total population of 42 272.

3.2.1 Wingecarribee Reservoir

Wingecarribee Reservoir is located on the Wingecarribee River, about 15 km southeast of Bowral, NSW. The reservoir is an earth and rockfill dam that was completed in 1974, and it is owned and operated by the Sydney Catchment Authority (SCA). In addition to several other Southern Highlands dams, Wingecarribee Reservoir is part of the Shoalhaven Scheme, which was built in the 1970s and designed as a dual-purpose water transfer and hydro-electric power generation scheme. The reservoir has a capacity of 25 900 ML and a small direct catchment area of 40 km^2, though it draws water from the greater Fitzroy Falls catchment area. The Wingecarribee Reservoir's original storage capacity was 34 500 ML, but around 9 000 ML of this capacity was lost as a result of the inflow of peat from the Wingecarribee Swamp collapse in August 1998. Water from the Wingecarribee Reservoir is distributed to Southern Highlands communities including Bowral, Mittagong and Moss Vale, after treatment at the Wingecarribee WTP.

The reservoir draws water from the Wingecarribee River. The Wingecarribee River sub-catchment includes large tracts of mainly forested land and several nature reserves. Surrounding the Wingecarribee Reservoir is a special area classification designating restricted entry. The reservoir is not open to the public for any recreational purposes.

3.2.2 Wingecarribee Reservoir raw water quality

A summary of Wingecarribee Reservoir's water quality is provided in Table 3. A detailed water quality data analysis is provided in Section 4. In summary:

- the raw water from Wingecarribee Reservoir has consistently low measured turbidity and also typically low true colour levels (although true colour data available for this study were limited);
- the raw water from Wingecarribee Reservoir has relatively low alkalinity and hardness concentrations indicating that Wingecarribee raw water is probably poorly buffered (more prone to pH change), and possibly corrosive. Consistent with this, the raw water pH data were "scattered", and showed a fair amount of variability. Occasionally measured pH has risen > 9, possibly as a result of algal blooms in the reservoir (photosynthesis removing carbon dioxide);

- the raw water from Wingecarribee Reservoir has relatively low dissolved oxygen levels, and elevated iron and manganese levels have been reported;
- there are seasonal changes in cyanobacterial counts with peaks rising to 622 000 cells/mL in summer months.

Table 3 Raw water quality fed to Wingecarribee WTP

Parameter	Observation
Turbidity	Typically < 10 NTU; always < 15 NTU
E.coli	Often < 10 / 100 mL and spike up to 16 000 / 100 mL
Manganese	0.025 - 0.062 mg/L
True colour	Typically 30 - 60 Hu
pH	6.9 – 9.8
Alkalinity	15 - 20 mg/L as $CaCO_3$
Hardness	20 - 25 mg/L as $CaCO_3$
DOC	5 mg/L
Cyanobacterial counts	Total cyanobacterial counts up to 622 000 cells/mL; median *ca.* 100 000 cells/mL. Toxic counts are
TDS	Approx. 50 mg/L at surface; 160 mg/L at depth of 10 - 15 m

3.2.3 Wingecarribee water treatment plant

Wingecarribee WTP typically treats about 10 ML/d, though it can treat in excess of 20 ML/d in the summer months. Water is treated by using the following processes (Figure 2):

- pre-lime dosing;
- coagulation / flocculation (dosing alum and polymer);
- dissolved air flotation (DAF) clarification;
- sand filtration;
- post-filtration pH correction / stabilisation (lime dosing); and
- chlorination (Cl_2 gas).

3.2.4 Wingecarribee treated water quality

A detailed treated water quality data analysis is provided in Section 4. In summary:

- Chemical stabilisation is undertaken by post-lime dosing at Wingecarribee WTP. However, pH at the WTP outlet varies between 7 and 9, which is consistent with a poorly buffered water of low alkalinity (*i.e.* water may be corrosive).
- Wingecarribee WTP generally reduces turbidity to < 1 NTU in treated water; however, there are records of treated water with turbidity of 2 - 4 NTU. Filtered water turbidity data from the treatment

- Wingecarribee WTP typically reduces true colour values down to < 3 Hu, which suggests that dissolved organic carbon (DOC) reduction is also achieved;
- Concentrations of manganese in Wingecarribee treated water are relatively high (Table 3) and removal rates at the WTP suggest that there is no process for reduction of soluble manganese, although supplied water concentrations are within the *ADWG* suggested aesthetic upper limit of < 0.1 mg/L.

3.3 Removal of microbes by water treatment

The *ADWG* and the World Health Organization's (WHO) *Guidelines for Drinking Water Quality* (2004) both state that the greatest health risks to drinking-water consumers arise from the potential presence of microbiological pathogens (generally bacterial, viral or protozoan pathogens) in the water supply. Water treatment can remove or reduce the concentrations of microbial organisms that may have been present in the raw water. To assist this assessment, the potential for reductions of microbes that could be achieved at the Wingecarribee and Goulburn WTPs were compared.

Suitable data (*i.e.* microbial counts in the raw and treated waters) were not available to allow a direct estimation of the microbial reductions achieved at each treatment plant. An assessment of the log reduction[2] potential at each plant was made based on literature reported values (Black *et al.* 2009; Signor, 2007; Hijnen *et al.* 2006; USEPA, 2006; LeChevallier & Au 2004); the outcome is in Table 4. Based on the information in Table 4 and the description of the treatment processes in Figure 2, the Goulburn WTP would typically provide an additional 3 $\log_{10}$ removal of protozoa and bacteria and similar (though slightly better) virus removal capabilities as compared to Wingecarribee WTP.

Table 4 Indicative log reductions from well operated validated treatment processes

Treatment process	Dose/Ct[a]	Log reductions		
		Virus	Bacteria	Protozoa
Coagulation, sedimentation and filtration		1	1	3
DAF		2	2	1
Chlorine	10 mg.min/L	2	4[b]	0
	20 mg.min/L	4	4[b]	0
UV light	55 mJ/cm^2	1	4[b]	4[b]
	110 mJ/cm^2	2	4[b]	4[b]

[a] Ct = concentration x disinfection contact time; [b] A maximum 4 log reduction allocated to disinfection barriers

3.4 Land use in the vicinity of the pipeline

The proposed pipeline would traverse land that is largely either forested or used for grazing. Near East Goulburn, the pipeline would underlie land that receives irrigation water supplied from the Goulburn wastewater treatment plant.

[2] A $\log_{10}$ reduction of 1 indicates a 90 percent removal of microbes, 2 indicates 99 per cent, 3 indicates 99.9 per cent, *etc.*

4. Water Quality Data

This section contains the outcomes of a water quality data analysis that was undertaken with an aim of assisting with the identification of potential drinking water quality impacts. Broadly, the Project would potentially impact on the quality of drinking water being supplied to Goulburn in the following ways:

- in the event that the raw water transfer option was adopted –
  - the new water source could have different characteristics to the current raw water supply for Goulburn, and these differences could result in the Goulburn WTP producing treated water with different quality characteristics as compared to the present supply; and/or
  - the new water source may introduce new loads of contaminants (*e.g.* microbes or algae) that could challenge or pass through the existing Goulburn WTP.
- in the event that the treated water transfer option was adopted, there could be differences in the quality and characteristics of the water currently received by Goulburn residents and other users, and that which would be delivered from the Wingecarribee WTP via the proposed pipeline.

Data on a series of key water quality indicators were collected from the raw and treated waters of the Goulburn and Wingecarribee systems, and compared. The following report sections detail the findings of the assessment for each water quality indicator data that was reviewed. Each concludes with a preliminary comment on the implications for Goulburn's drinking water quality that may be brought about by the Project. These are elaborated on in Section 5.

4.1 Turbidity

Data from Wingecarribee Reservoir demonstrates consistently low turbidity values, with values generally < 10 NTU and always < 15 NTU.

Goulburn raw water turbidity is typically lower than that of Wingecarribee Reservoir, particularly in recent years, however, the trend is more variable and historic data demonstrates frequent peaks > 20 NTU and occasionally as high as 80 NTU. This is consistent with Goulburn WTP being supplied by multiple raw water sources with possibly varying water quality (Section 3.1.1). In contrast, Wingecarribee Reservoir is fed from a consistent source.

In terms of Goulburn WTP's capability in reducing turbidity, Figure 3 demonstrates that it routinely reduces raw water turbidities of 8 - 10 NTU down to < 1 NTU. Peaks in treated water turbidity were only viewed as significant when they rose above 1 NTU (due to potential shielding of pathogens against effective chlorination).

When challenged with peak raw water turbidity (30 – 80 NTU) Goulburn WTP usually achieves treated water turbidities <1 and always < 1.5 NTU. These results indicate that Goulburn WTP would be capable of adequately reducing the turbidity of the raw water that may be supplied from Wingecarribee Reservoir.

In terms of Wingecarribee WTP's capability to reduce turbidity, Figure 4 demonstrates that it generally reduces raw water turbidities of 6-14 NTU down to < 1.5 NTU, but that filtered water is generally < 0.6 NTU. Furthermore, treated water turbidity values of 2 -4 NTU were recorded in February 2009 and values up to 9 NTU were recorded in September 2008, however, filtered water turbidities remained low during these periods. It is likely that elevated treated water turbidities for Wingecarrbee WTP are due to lime dosing post-filtration. Lime dosing adds inert particles, but these do not adversely affect chlorination.

Under the raw water transfer option, if Wingecarribee raw water dominated the blend fed to Goulburn WTP, then there would be less variability in raw water turbidity, possibly making it operationally easier to treat. During pipeline re-start after a stagnant period, there could be some re-suspension of settled particles, resulting in a 'first flush' turbidity spike. However, the data suggests that Goulburn WTP is robust against spikes in feed water turbidity.

Under the treated water transfer option, there would likely be minimal changes in turbidity levels of the water supplied to Goulburn, unless post-filtration lime dosing (at Wingecarribee WTP) causes turbidity in treated water to rise above 5 NTU, in which case the water may breach the ADWG aesthetic value for turbidity. However as the increased turbidity in water from the Wingecarribee WTP is due to post filtration lime dosing, it is unlikely that this would impact on the disinfection performance provided by chlorine residuals in Goulburn's piped network.

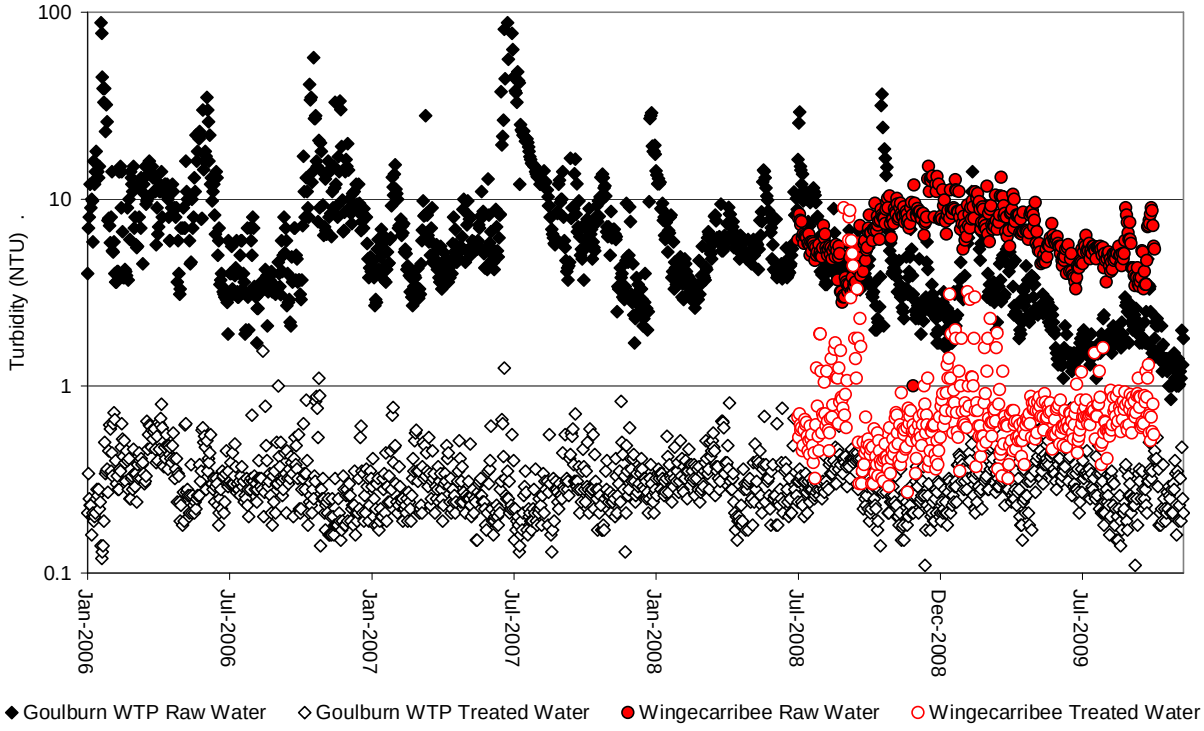

Figure 3 Raw and treated water turbidity for Goulburn and Wingecarribee water supplies

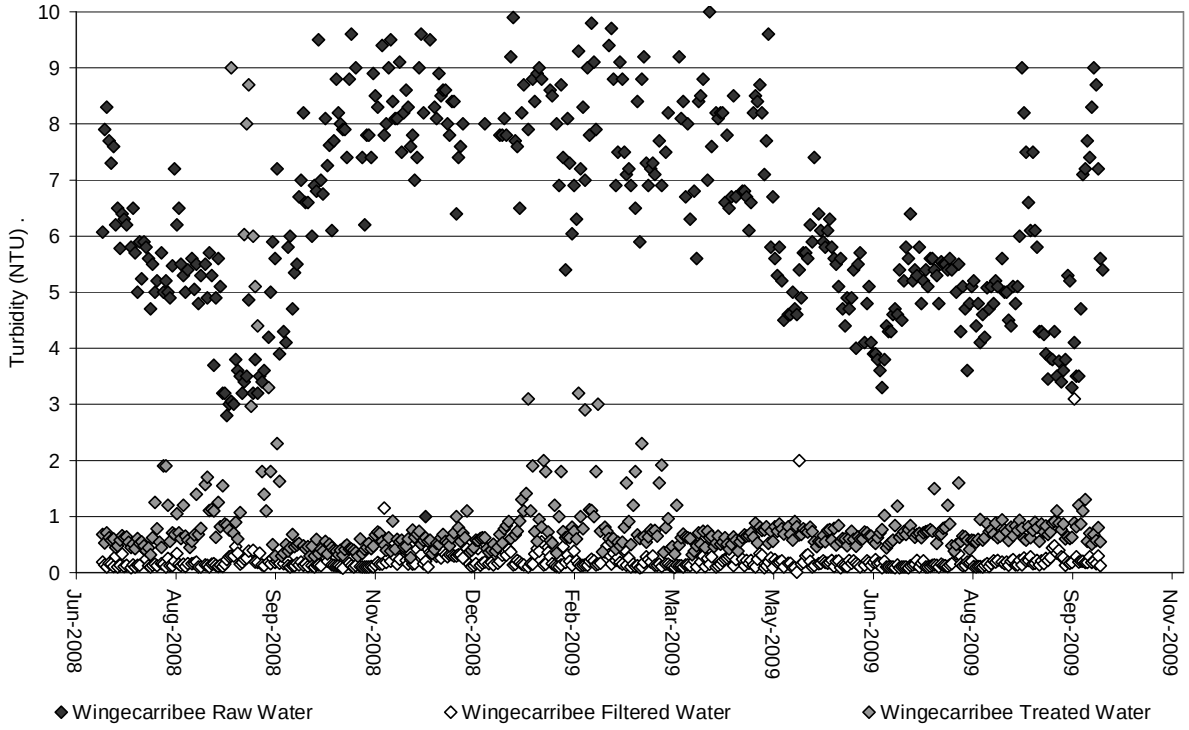

Figure 4 Turbidity of raw, filtered and treated water from Wingecarribee WTP

4.2 Colour

The *ADWG* recommends that true colour values be < 15 Hu for aesthetic purposes.

Goulburn raw water true colour data is typically 100 - 300 Hu but frequently spikes to > 500 Hu (Figure 5). These data reflect that Goulburn WTP is supplied by multiple raw water sources and that these can be variable in quality (Section 3.1.1). Goulburn WTP supplies treated water with true colour values consistently < 10 Hu.

Wingecarribee Reservoir true colour values typically vary between 30 – 60 Hu and the trend is more consistent (less spiking) than at Goulburn, although data is limited. The Wingecarribee WTP supplies treated water with true colour values < 3 Hu.

True colour data are sometimes used to indicate the likely DOC concentrations in raw waters. Figure 5 is consistent with DOC data presented in Figure 6 (*i.e.* Goulburn raw DOC is generally twice that recorded in Wingecarribee Reservoir).

Under the raw water transfer option, Goulburn WTP would experience lower and less variability in raw water true colour, possibly making it operationally easier to treat. However, intermittent use of the pipeline could result in greater extremes of true colour in feed water. As Goulburn WTP already treats raw water with highly variable true colour, this would be unlikely to cause operational difficulty simply to optimise colour removal. (NB: operational difficulties linked to variable alkalinity and pH adjustment are a different matter as discussed below).

For the treated water transfer option, there is no evidence suggesting that Wingecarribee WTP performs inadequately in terms of true colour removal. True colour of the water treated at the Wingecarribee WTP is generally lower than in Goulburn's present water supply.

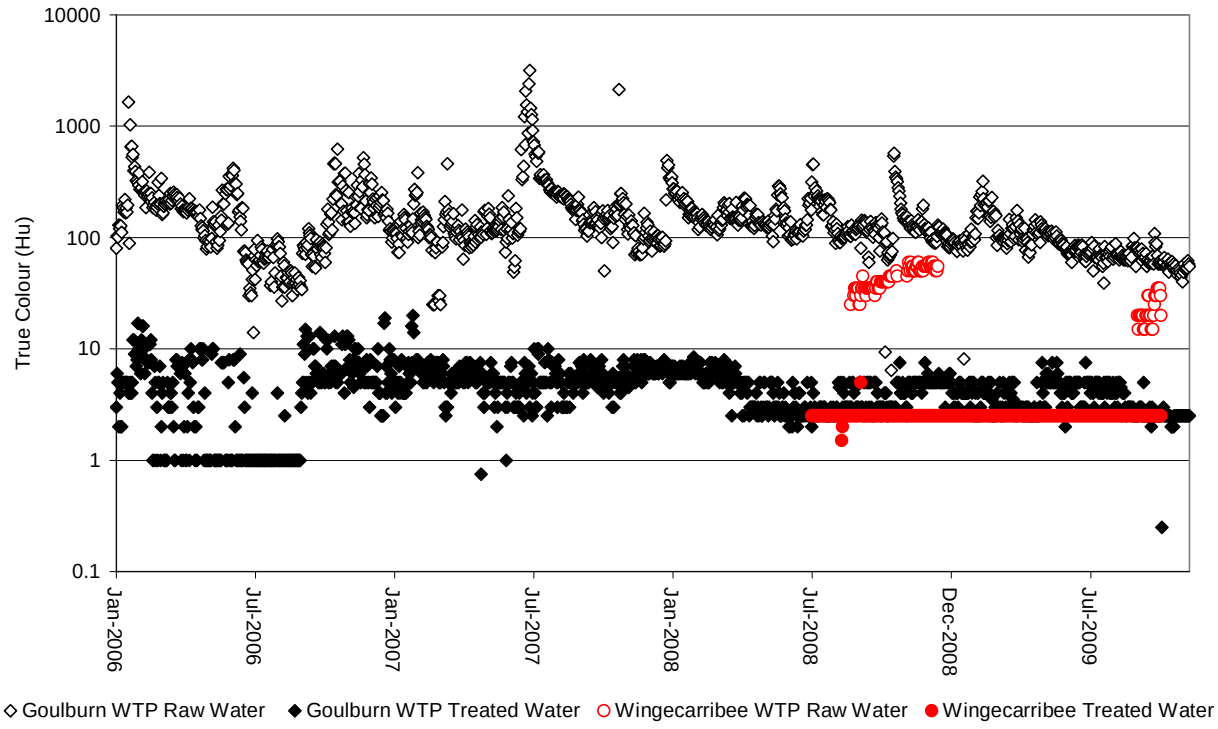

Figure 5 Raw and treated water colour for Goulburn and Wingecarribee water supplies

4.3 Dissolved organic carbon

Dissolved organic carbon (DOC) is of interest because high levels in the treated water prior to chlorination can increase the potential for undesirable disinfection by-products (DBPs) formation.

DOC in Goulburn WTP's source water is typically 6 – 12 mg/L (Figure 6). Concentrations are typically lower in Wingecarribee Reservoir (*ca.* 5 mg/L).

Goulburn WTP's capability to remove DOC is not directly assessable (in the absence of DOC data for filtered water). However, the WTP does reduce true colour (Figure 5) and this can be used as a surrogate for its ability to remove DOC. The treatment processes in place (coagulation, flocculation, clarification and filtration) also generally are suited to removing organics from the water. The same observations are true of Wingecarribee (*i.e.* the WTP has suitable treatment processes to remove DOC and it might be inferred from true colour data that DOC is adequately removed).

For the raw water transfer option the lower DOC concentrations observed in Wingecarribee's source water, combined with Goulburn WTP's demonstrated capability to handle water with variable DOC concentration, would mean that it is likely that there would be a reduction in DOC concentrations in water being supplied to Goulburn. As such, there is perhaps a lower risk of disinfection by-product formation (DBP) in Goulburn's distribution system, as compared to the present situation.

For the treated water transfer option, the impact on the DOC content in water being delivered to Goulburn is unknown since filtered water DOC data were not available from the Wingecarribee system. However, if it is assumed that the lower true colour measurements in the Wingecarribee treated water also translates to lower DOC concentrations, there would likely be a lower risk of DBP formation in Goulburn's distribution system, as compared to the present situation.

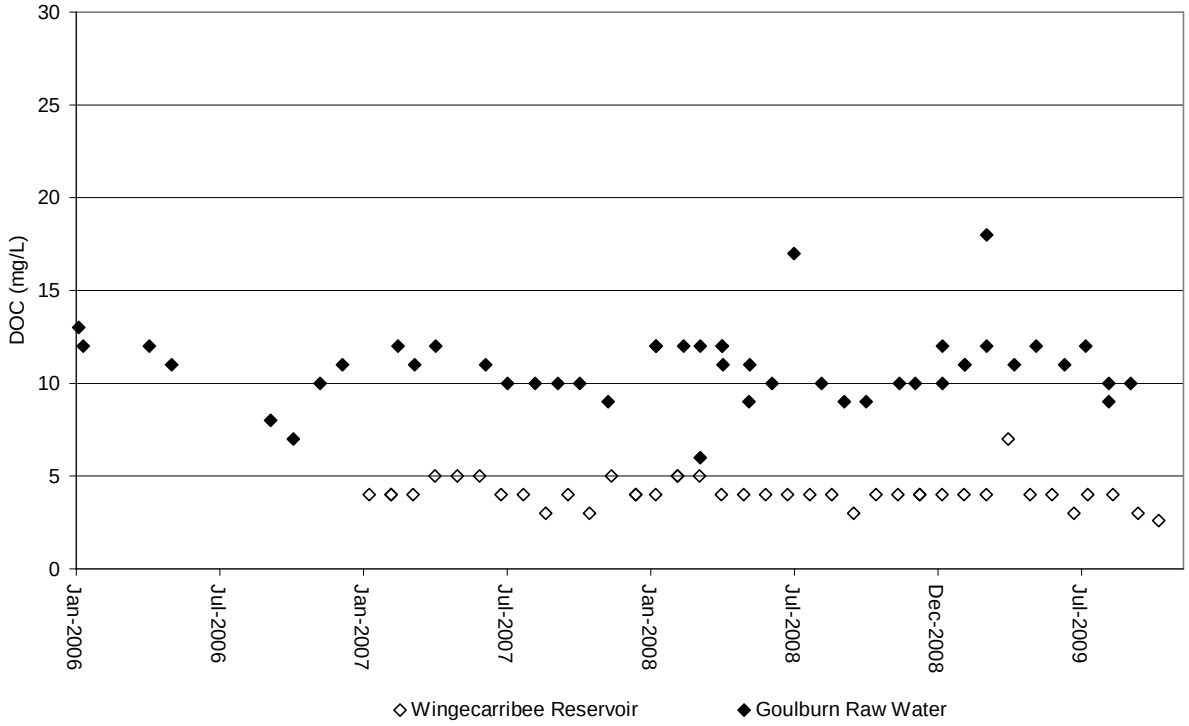

Figure 6 Raw water DOC for Goulburn and Wingecarribee water supplies

4.4 Blue-green algae

Cyanobacteria data are presented in Figure 7-Figure 9. There is a seasonal trend, with blue-green algae blooms occurring generally every summer in each water source. The audit of Sydney's catchments in 2007 (DECC, 2007) identified that the Wingecarribee River was one of the most vulnerable waterways to nutrient intrusion in the region, which may explain the algal bloom history there.

Wingecarribee raw water usually exhibits higher counts than the Goulburn raw sources, but generally counts have been sufficiently high in both raw waters to warrant inclusion of treatment processes specifically to remove cyanobacterial cells and toxins at both WTPs (*e.g.* PAC). There have been recent reported incidences at Wingecarribee Reservoir where cyanobacteria levels have exceeded *ADWG* limits. On these occasions, PAC was employed to adequately treat the water to continue supplying water to Wingecarribee Shire customers (SCA, 2009).

Figure 9 shows that some of the cyanobacteria detected in Wingecarribee Reservoir have been confirmed as toxic. No equivalent data was available for Goulburn raw water. Therefore, it was not possible to use 'toxic cyanobacterial counts' data to determine whether the PAC process at Goulburn would need to be run more frequently under the raw water transfer option. However, based on total cyanobacterial counts, it is likely that GMC would be required to dose PAC more frequently at Goulburn

WTP under this scenario. This would also depend on the proposed operational strategy for the pipeline (and whether, for example, Wingecarribee raw water might be avoided when cyanobacterial counts are known to be high).

For the raw water transfer option (and assuming continual, rather than intermittent pipeline operation), it is likely that the Goulburn WTP would be challenged by increased loads of cyanobacteria, resulting in a need to use PAC dosing more frequently than is currently the case. In the event where cyanobacteria levels in the Wingecarribee Reservoir would pose an unacceptable health risk to Goulburn water consumers, GMC would have the option of ceasing supply from the pipeline and relying on the current water sources.

For the treated water transfer option, it is likely that there would be an increased risk to Goulburn's water customers from cyanobacteria. This is due to the higher algae counts typically present in Wingecarribee Reservoir. However, historically the Wingecarribee WTP has been able to manage and continue supply of water during bloom periods in the reservoir.

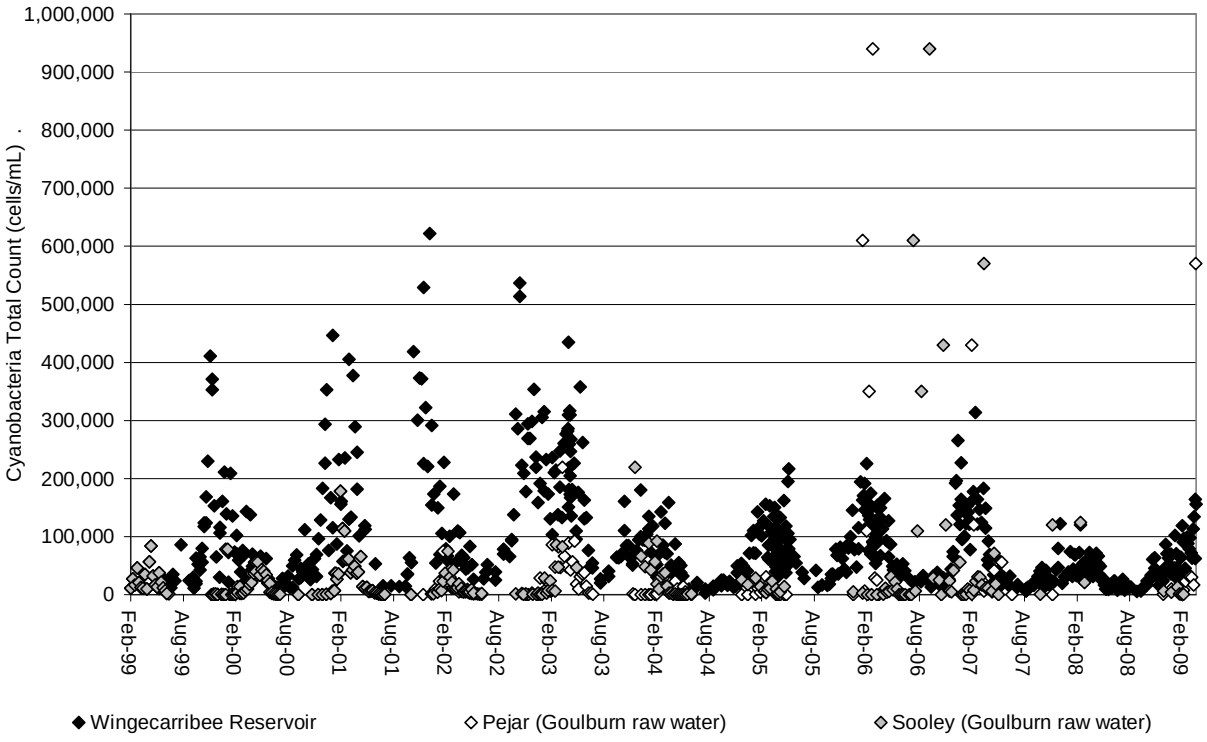

Figure 7 Total cyanobacterial counts in Goulburn and Wingecarribee raw waters

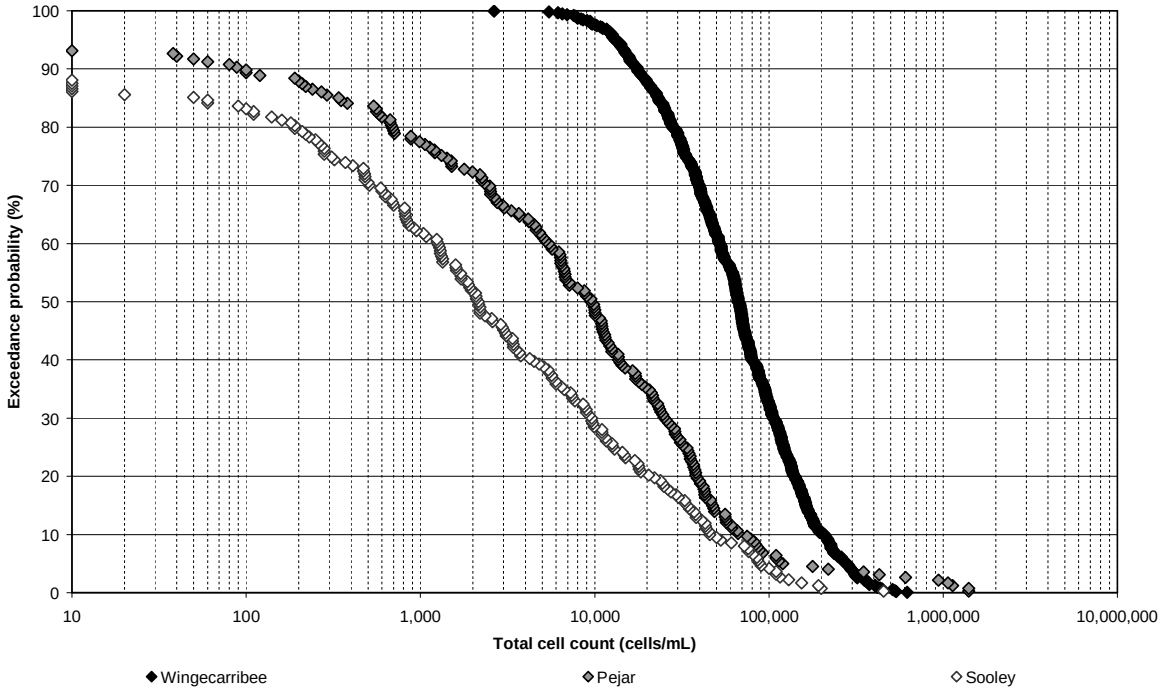

Figure 8 Exceedance probability chart of cyanobacterial counts

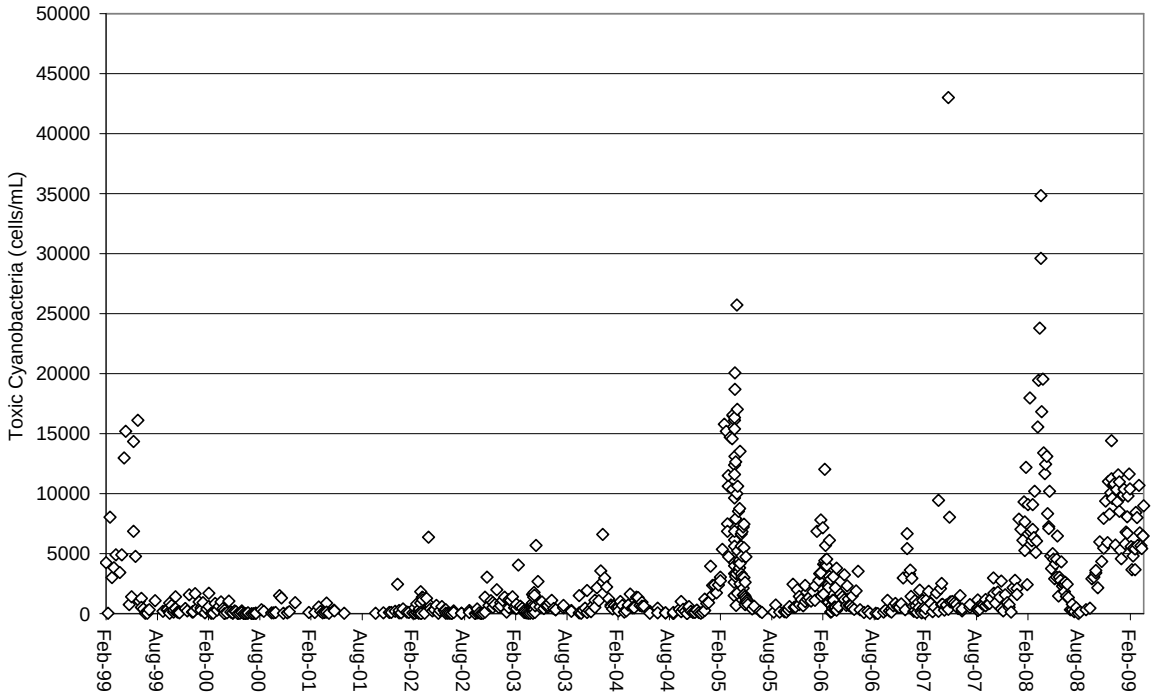

Figure 9 Toxic cyanobacteria counts in Wingecarribee Reservoir

4.5 *Escherichia (E.) coli* and microbial pathogens

E. coli is a commonly used indicator of the level of faecal contamination that may present in water. Often, higher levels of *E. coli* presence in the water can indicate the potential for higher concentrations of other faecal pathogens that can pose a risk to human health, such as *Cryptosporidium*, *Giardia* or viruses; though *E. coli* can have limitations as an indicator (as described in the *ADWG*). Key sources of faecal contamination can include agricultural activity (especially cattle and sheep waste) and urbanised areas (human waste). Both the Wingecarribee Reservoir and Wolondilly River (Goulburn) catchments support some agricultural and urban landuse (DECC, 2007).

No raw water *E.coli* data were available for Goulburn, so it was not possible to assess Goulburn WTP's capability at removing *E.coli* or directly ascertain whether the Wingecarribee raw water would present any additional challenge to the Goulburn WTP. However, *E. coli* monitoring results from Goulburn's water distribution network have indicated that *ADWG* requirements for treated water (*i.e.* nil detection of *E. coli* in 98 per cent of 100 mL samples taken from the distribution network) have been met over the past few years. The information in Table 4 suggests that, when well operated, the Goulburn WTP would be able to handle *E. coli* counts in the order of 10^5 organisms/100 mL.

E.coli counts in the Wingecarribee Reservoir are typically > 10 / 100 mL and prone to spiking up to 16 000 / 100 mL (Figure 10). These spikes probably coincide with rainfall events within the catchment. This is consistent with levels typically observed in partly impacted catchments (*e.g.* Roser & Ashbolt, 2007). No treated water *E.coli* data were available from the Wingecarribee WTP so as to assess Wingecarribee WTP's microbial removal capability; however, the existing barriers at Wingecarribee WTP (conventional treatment, DAF + chlorination, see Table 4) should be adequate to remove (or inactivate) the levels of *E.coli* detected in Wingecarribee Reservoir to *ADWG* requirements.

The Goulburn WTP has multiple treatment barriers, including coagulation, filtration and chlorine + UV disinfection. For the raw water transfer option, it is not likely that there would be a development of risks posed by the presence of microbes in the treated water supply to Goulburn that were unacceptable, as:

- *the Wingecarribee Reservoir is already used as a drinking water source; and*
- *the existing barriers at Goulburn WTP, including UV and chlorine disinfection steps, provide even more control of microbial water quality than the Wingecarribee WTP provides.*

Additionally, the current treatment processes at Goulburn would likely be adequate to remove (or inactivate) the levels of E.coli that have been measured in Wingecarribee Reservoir down to meet ADWG requirements.

For the treated water transfer option it is presumed that adequate treatment at Wingecarribee WTP already produces water with microbial content that meets the ADWG for Wingecarribee customers.

NB: The Sydney Catchment Authority is also currently undertaking a series of catchment management projects that would benefit the catchment health and the management of risk to health from microbes throughout the entire Sydney catchment area (for example, see DECC, 2007).

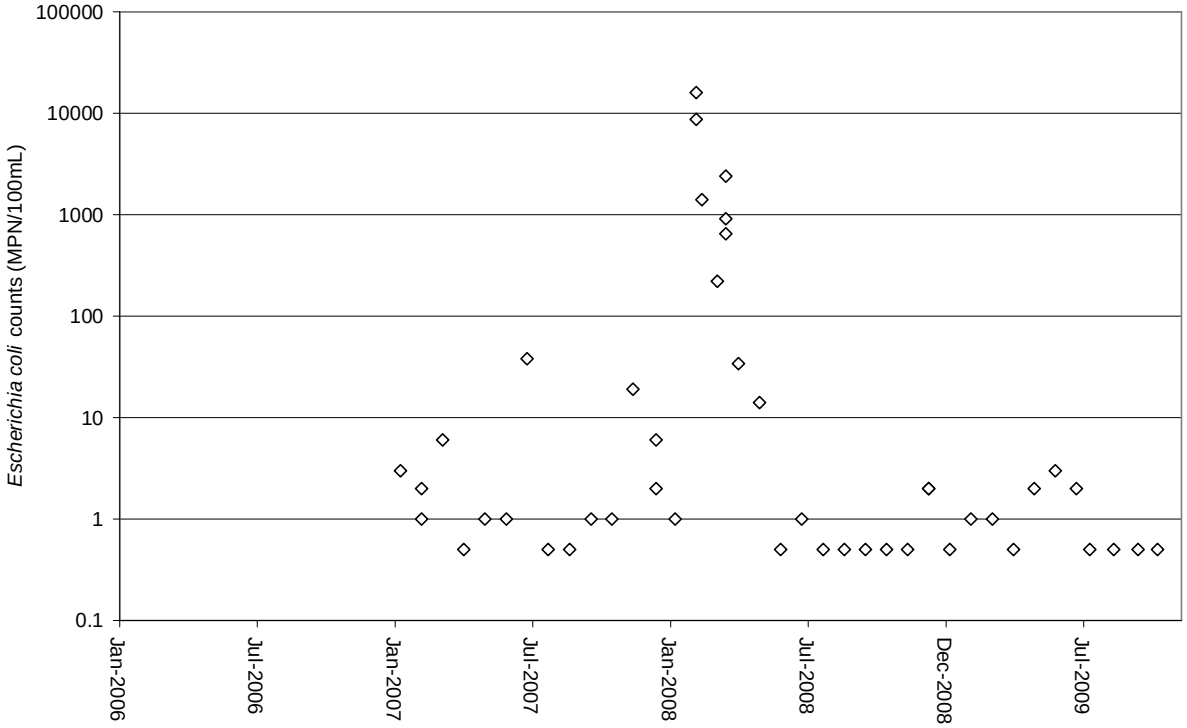

Figure 10 *E.coli* counts in Wingecarribee Reservoir

4.6 Alkalinity, hardness and total dissolved solids

Wingecarribee raw water is significantly softer and less well buffered than Goulburn raw water. Goulburn raw water typically has (Figure 11 - Figure 13):

- Alkalinity of 80 - 140 mg/L as $CaCO_3$, but occasionally dropping as low as 30 mg/L as $CaCO_3$;
- Hardness of 100-250mg/L as $CaCO_3$;
- TDS varying between 100 – 500 mg/L;

In contrast, Wingecarribee Reservoir water has:

- Alkalinity consistently between 15 – 20 mg/L as $CaCO_3$;
- Hardness of approx. 20 - 25 mg/L as $CaCO_3$;
- TDS of *ca*. 50 mg/L at the reservoir surface and rising to 160 mg/L at a depth of 10 - 15 m.

To put these concentrations into context, the *ADWG* recommends keeping TDS in treated water below 500 mg/L for aesthetic reasons and maintaining hardness in treated water below 200 mg/L as $CaCO_3$ to minimise scale formation.

For the raw water transfer option, the aesthetic quality of the water that is associated with TDS and hardness would probably improve, as Wingecarribee raw water would dilute Goulburn raw water and reduce hardness and mineral-induced taste in treated supply.

It is also possible that less sulphuric acid dosing would be needed to adjust pH prior to coagulation at Goulburn WTP, since the feed water would be less buffered, although this would depend on the pH of influent water from Wingecarribee Reservoir.

It is important to note that these effects would also depend on the proportion of raw blend from each source and the operating strategy for the pipeline. Intermittent use of the pipeline would lead to greater extremes in hardness, alkalinity and TDS in feed water to Goulburn WTP increasing the risk of suboptimal treatment at the Goulburn WTP.

For the treated water transfer option, there is a possibility that customers living in the 'mixing zone' (between Goulburn WTP and Wingecarribee WTP supplies) would experience variability in hardness (and other water quality characteristics) which could give rise to complaints to GMC. The differences in treated water hardness between the two WTPs would be noticeable in terms of taste and other aspects. However, customers who consistently receive treated water from Wingecarribee WTP (and hence less hard water) would likely have fewer issues with scaling of appliances (kettles, irons, etc). Again, the exact nature of any impacts would be dependent on the operating strategy for the pipeline.

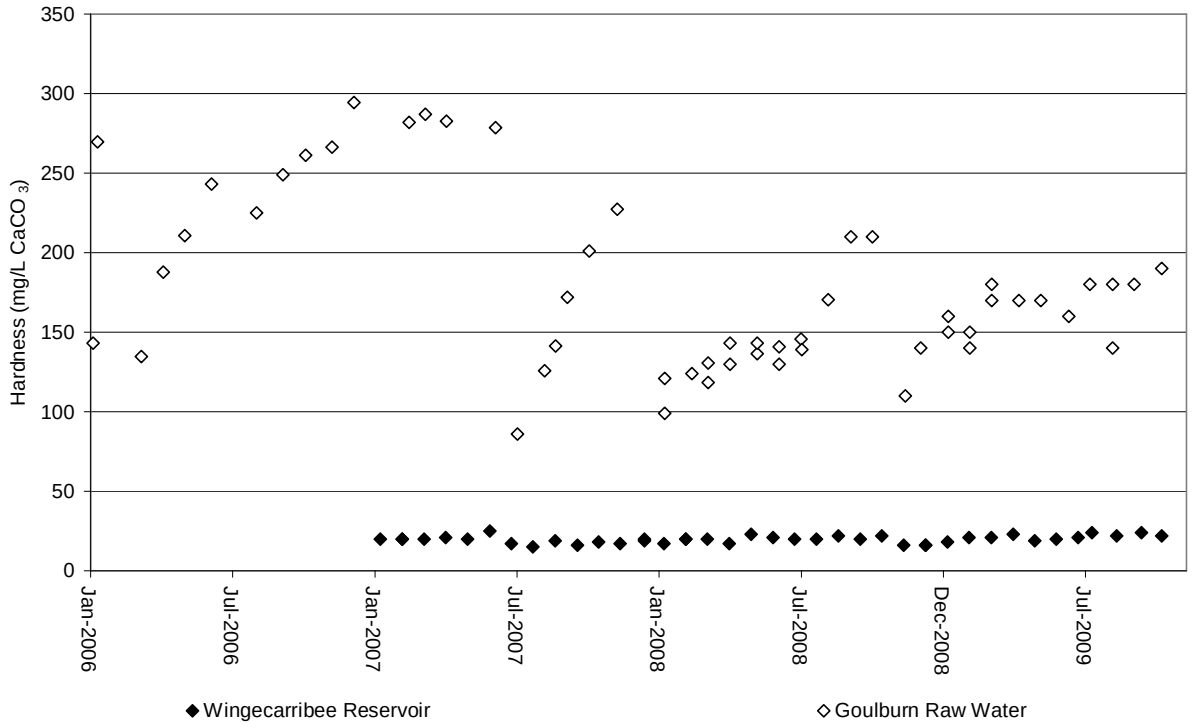

Figure 11 Hardness in Goulburn and Wingecarribee raw waters

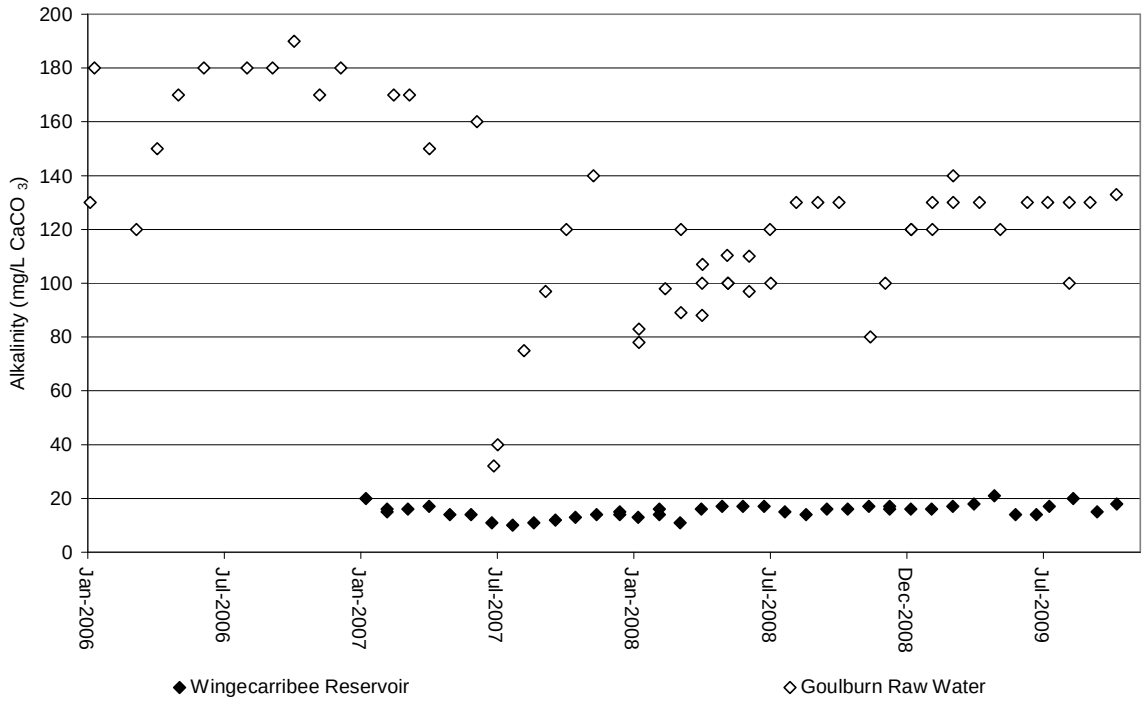

Figure 12 Alkalinity in Goulburn and Wingecarribee raw waters

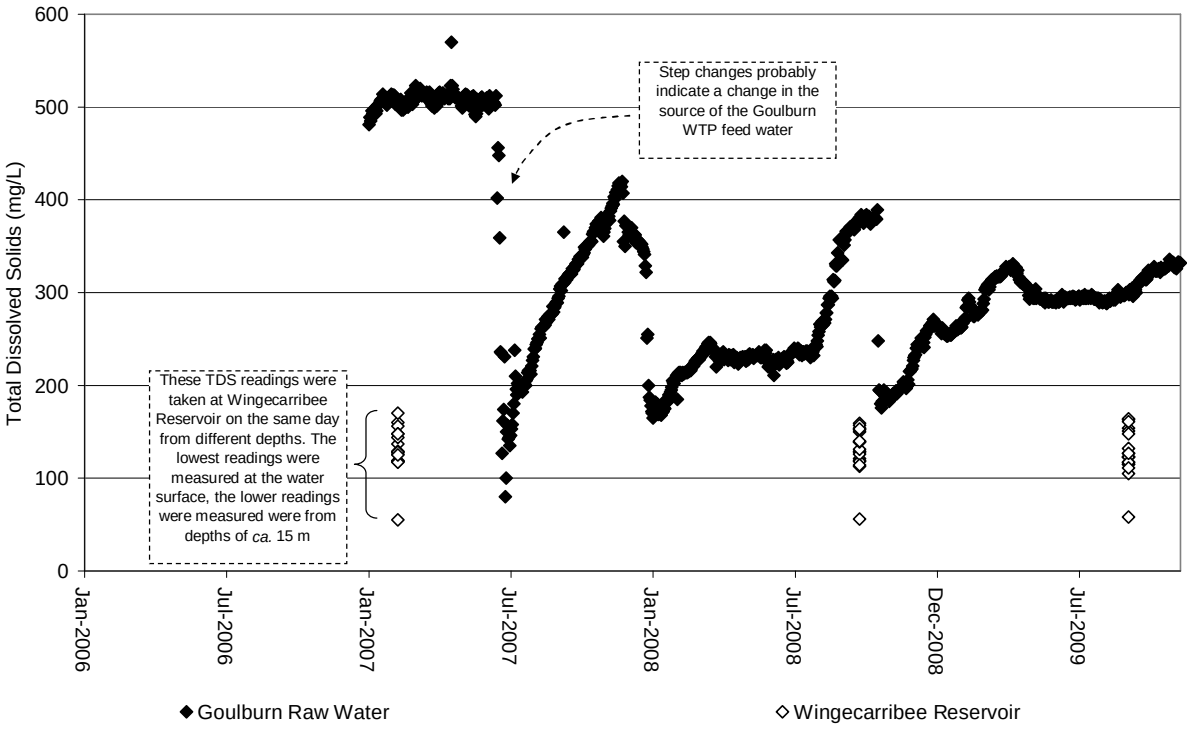

Figure 13 TDS concentrations measured in Wingecarribee and Goulburn raw water

4.7 Water stability and corrosion (pH, alkalinity, hardness)

Wingecarribee raw water is low in hardness and alkalinity, while in Goulburn's raw water these are variable and frequently high (Section 4.6). Hence, the Wingecarribee water is likely to be less buffered (*i.e.* more prone to pH change) and more corrosive (*i.e.* less chemically stable) than the current Goulburn sources. This is reflected in pH data for both sources - Goulburn's raw water pH (7.0 - 8.0) is more stable than Wingecarribee's (6.9 – 9.8). The pH variability at Wingecarribee Reservoir may be induced by algae growth (photosynthesis removing CO_2 and increasing pH). For example, a spike in pH in February / March 2009 occurred at the same time as a late summer algal bloom.

In terms of treated water, Figure 15 shows that pH control is a challenge at the Wingecarribee WTP, presumably due to the low alkalinity of the raw water. This supports the notion that the Wingecarribee treated water may be more corrosive (*i.e.* corrode pipes and fittings) than the present Goulburn supply.

For the raw water transfer option, a resultant decrease in the buffering capacity of raw water feed to the Goulburn WTP from the blending of the water sources may be advantageous in that less sulphuric acid dosing would be required to reduce pH. However, this only applies when Wingecarribee Reservoir water is not experiencing elevated pH (which it is prone to doing).

A greater degree of operator attention at Goulburn WTP would be needed to manage the feed water quality changes (pH control for pre-oxidation and coagulation). This would depend on the make-up of the blending, where blending takes place and also the pipeline operating strategy.

For the treated water transfer scenario, there could be aesthetic problems with an increased potential for corrosion of the reticulation system causing a change in the taste and colour of the water at customer taps.

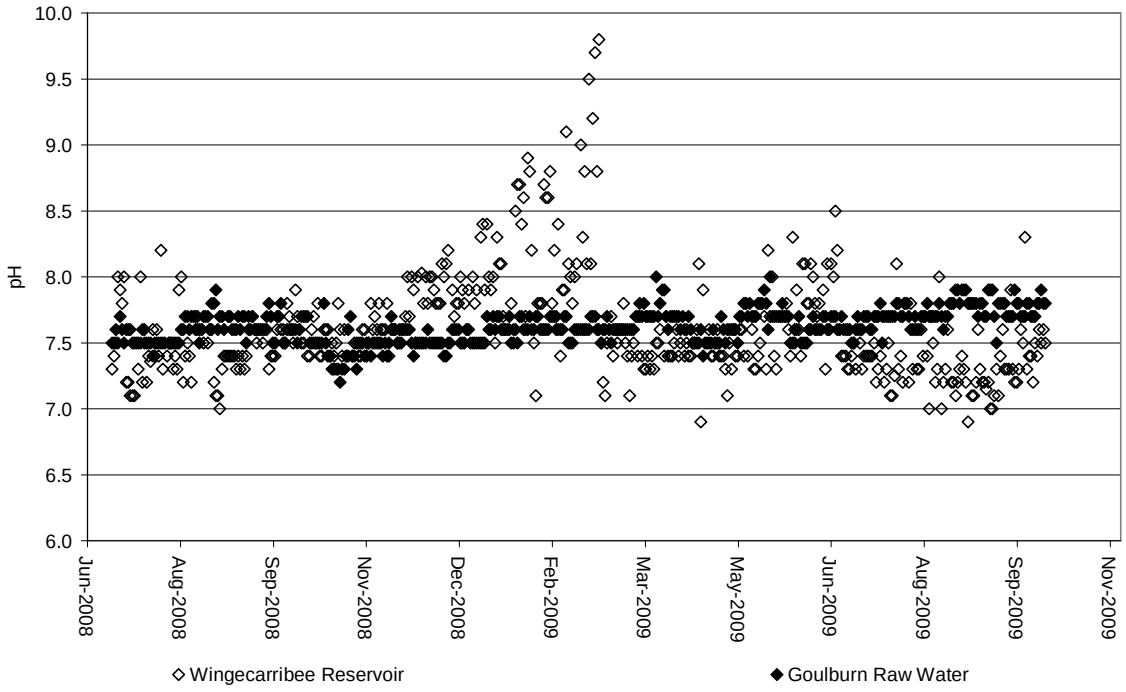

Figure 14 pH of Goulburn and Wingecarribee raw waters

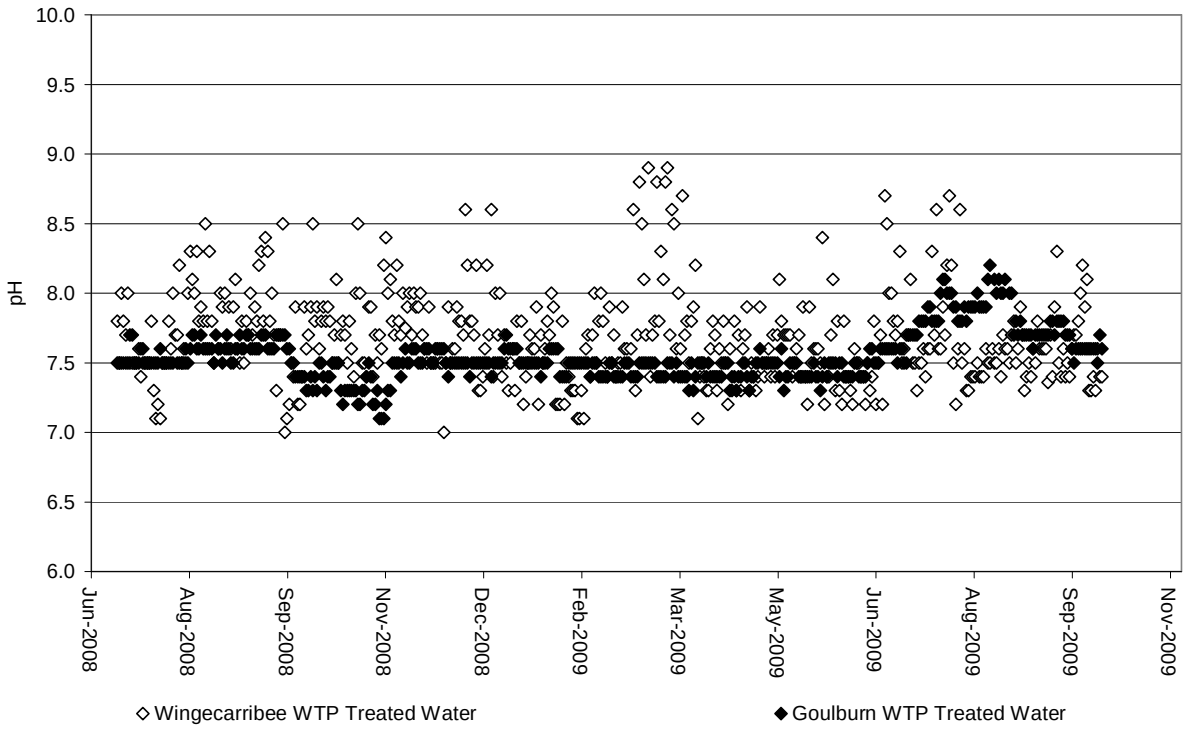

Figure 15 pH of treated water from Goulburn and Wingecarribee WTPs

4.8 Manganese

The *ADWG* indicate that aesthetic problems can arise when manganese concentrations are > 0.1 mg/L and health risks at concentrations > 0.5 mg/L in drinking water. It is common in Australia to aim for treated water soluble manganese concentrations < 0.02 mg/L to assist with minimising biofilm growth in pipelines.

Soluble manganese was reported as posing a significant challenge to the Goulburn WTP in 2003, particularly when raw water was sourced from the Sooley Dam (Hunter Water, 2003). To manage this, a potassium permanganate dosing plant has since been installed at the Goulburn WTP.

Figure 16 shows that Wingecarribee Reservoir experiences total manganese concentrations of 0.025 – 0.065 mg/L and that these are reduced to < 0.045 mg/L in treated water. This observed reduction is probably associated with the removal of the insoluble manganese. A review of treatment processes at Wingecarribee WTP by GMC & DoC (2007) did not report any potassium permanganate or similar pre-oxidation chemical dosing being undertaken there. Concentrations recorded in treated water imply that Wingecarribee WTP does not have the same capability to remove manganese as the Goulburn WTP.

The treated water manganese concentrations recorded in Wingecarribee treated water are high enough to be associated with a high potential for growth of biofilm in the pipeline.

For the raw water transfer option, the drinking water quality risks associated with manganese concentrations that have been observed in the Wingecarribee Reservoir would likely be well managed by the potassium permanganate dosing systems that exist there. However, the high manganese concentrations in the Wingecarribee water may create biofilm issues within the pipeline (see below).

For the treated water transfer option, the higher manganese concentrations in the Wingecarribee raw and treated waters may present an increased potential for the growth of biofilms in the transfer pipeline and Goulburn distribution system. The ADWG indicates an aesthetic limit for manganese of 0.1 mg/L, but notes however that even at concentrations of 0.02 mg/L, manganese can form a coating on pipes that can slough off as a black substance. Generally it is desirable to reduce the concentration down to less than 0.01 mg/L, which seems to be well exceeded in the Wingecarribee treated water.

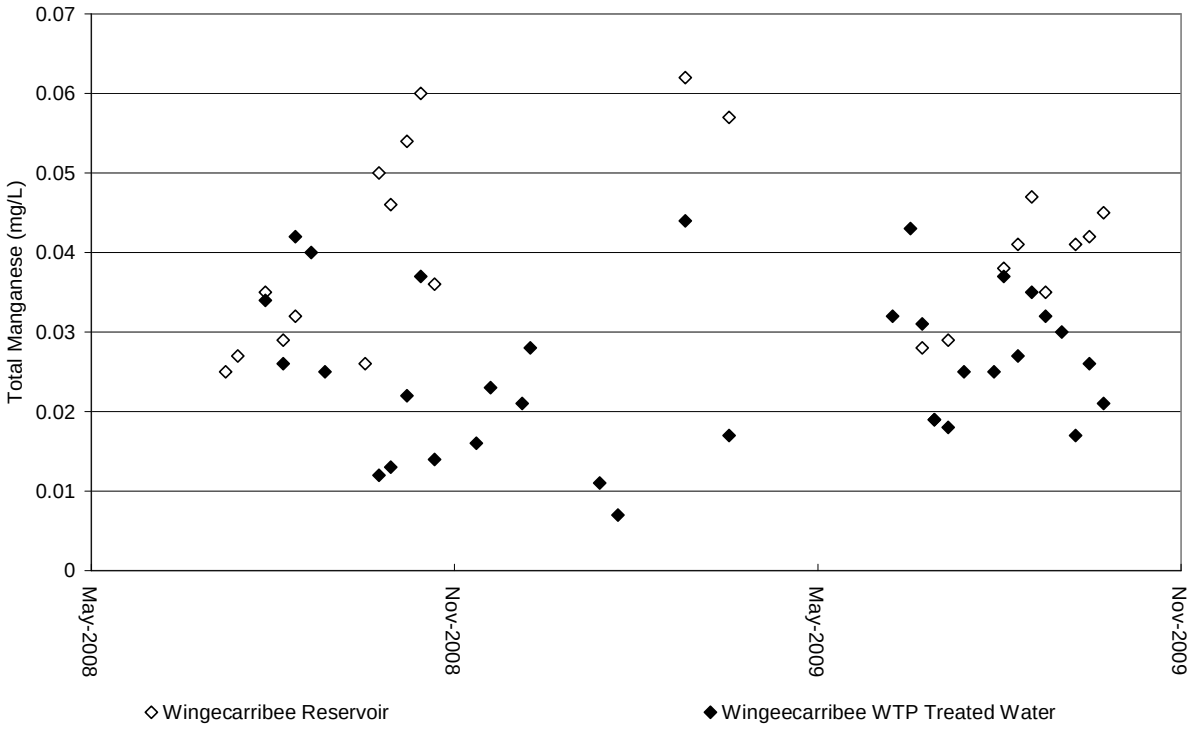

Figure 16 Total manganese concentrations in raw and treated water at Wingecarribee

4.9 Chlorine residual

A free chlorine residual (FCR) is required in treated drinking water to protect against microbial regrowth or contamination events that can happen within the distribution network. Chlorine residual can also help with mitigating biofilm growth in the distribution network.

No data were made available on FCR concentrations in the water at the Wingecarribee WTP outlet or Wingecarribee customer taps. A comparison of FCR at these two points would have been useful to examine the FCR decay characteristics of the Wingecarribee treated water. This information would have been used to examine for the treated water transfer option the need for booster chlorination stations along the pipeline to help maintain the residual. However, it would be likely that booster chlorination would be required given the length of the pipe (83 km) and the residence times within it (potentially up to two days when operating at full capacity, see Table 1).

For the untreated water transfer option, there would be unlikely to be any impact on the free chlorine residual in the water delivered to Goulburn customers, as all water would be treated at the Goulburn WTP.

For the treated water transfer option, it would be possible that the long residence times in the proposed pipeline would provide time for decay in the chlorine residual. This would need to be managed by providing booster chlorination stations along the pipeline length.

5. Impact Assessment

The primary documents referred to during the undertaking of this impact assessment were:

- *ADWG*;
- *A Guide to Hazard Identification and Risk Assessment for Drinking Water Supplies* (Nadebaum *et al.*, 2004);
- *Risk Assessment for Drinking Water Sources* (Miller *et al.*, 2009);
- *2007 Audit of the Sydney Drinking Water Catchment* (Department of Environment and Climate Change).

The focus of the impact assessment was to identify impacts that would possibly give rise to public health risks that would breach the requirement of the *Public Health Act 1991*, and how these risks would be managed. Impacts on the aesthetic nature of the water quality were also investigated.

5.1 Impact identification (rationale)

Relevant water quality data were reviewed from Wingecarribee and Goulburn raw and treated waters (Section 4). Preliminary comments on potential water quality impacts were provided at the conclusion of each of Sections 4.1 - 4.9.

Additionally, a number of targeted assessments were undertaken to answer specific questions aimed at identifying water quality impacts to Goulburn customers that may arise under each Project operating scenario, relative to the current water supply to Goulburn. The main aim was to determine whether new risks may arise, for example:

- from water quality differences at Goulburn customer taps, presented by the new raw source feeding Goulburn WTP. These might arise due to-
  - differences between Wingecarribee raw water quality and Goulburn raw water quality;
  - capability of the Goulburn WTP to treat Wingecarribee raw water; and
  - any existing weaknesses in the treatment process chain at Goulburn WTP (*i.e.* its 'treatment reliability') to treat its usual source water.
- from water quality differences at Goulburn customer taps, presented by the new treated water feeding directly into the Goulburn reticulation. These might arise due to -
  - any existing weaknesses in the treatment process chain at Wingecarribee WTP (i.e. 'reliability') to treat its usual (Wingecarribee raw) source water;
  - treated water quality changes within the proposed 83 km pipeline during the transfer of Wingecarribee water to Goulburn; and
  - differences between Wingecarribee treated water quality and Goulburn treated water quality and resultant water quality variation at Goulburn customer taps arising from the blending of the two treated waters.
- from water quality impacts or transformations that may arise during the transfer of the water through the proposed 83 km pipeline.

Five assessments were undertaken to assist in identifying possible drinking water quality impacts, namely:

- Assessment 1: Comparison of raw water quality at Goulburn and Wingecarribee ;
- Assessment 2: Reliability of Goulburn WTP;
- Assessment 3: Reliability of Wingecarribee WTP;
- Assessment 4: Comparison of treated water quality at Goulburn and Wingecarribee ;
- Assessment 5: Water quality changes that may occur during pipeline transfers.

Further details on each of these assessments are provided in Sections 5.1.1 - 5.1.5. The potential impacts identified were then examined by way of a risk assessment (Section 5.3) so as to prioritise those that may pose the greatest risks to drinking water consumers. This in turn was used to develop appropriate management strategies for consideration during the operation of the proposed pipeline.

5.1.1 Assessment 1: Comparison of raw water quality at Goulburn and Wingecarribee

This assessment involved comparing the raw water quality data available from the Goulburn and Wingecarribee systems. The aim was to examine whether the observed differences in water quality may result in water quality treatment challenges at the Goulburn WTP (in the event of raw water transfers) or other impacts on the water quality that may be supplied to Goulburn customers.

Time-series of the data were plotted to enable raw water quality comparisons of the Wingecarribee and Goulburn sources for the following: turbidity, true colour, alkalinity, pH, hardness, *E. coli*, total manganese, DOC, cyanobacterial counts, and toxic cyanobacterial counts.

The purposes of reviewing these charts were to examine:

- whether the water quality characteristics, in particular the observed average and ranges of contaminants and other quality indicators, were similar between the Wingecarribee and Goulburn raw water sources;
- whether raw water quality trends in each source water were similar (*e.g.* do they display similar temporal patterns, do the source waters tend to have periods of “contaminant spikes”, *etc.*). The reasoning was that differences in temporal patterns or contaminant spike behaviours may indicate new treatment challenges for the Goulburn WTP;
- the typical concentrations of DOC that have been detected in each raw water source. This information would be used to indicate whether there may any changes to the risk of trihalomethane (THM) formation within Goulburn’s chlorinated distribution system; and,
- the seasonality of cyanobacterial blooms recorded in both source waters, to address whether new or increased risks may be brought upon the Goulburn water supply system from the presence of blue-green algae in the raw water source.

5.1.2 Assessment 2: Reliability of Goulburn WTP

This assessment involved reviewing the current treatment capability (*i.e.* the ‘typically achieved’ removal of water quality contaminants) and the reliability (by considering the frequency of treatment ‘failures’ or occurrences of sub-optimal treatment) of the Goulburn WTP. These were considered by searching the

raw and treated water quality data from Goulburn and looking for periods where there has been deterioration in raw, treated or both water qualities.

The aim of this assessment was to identify what types of contaminants and contamination events in the raw water can challenge the Goulburn WTP, *i.e.* to which raw water contaminants and quality indicators is the Goulburn WTP's performance most sensitive? Once these water contaminants and quality indicators were identified, raw water quality data for the same parameters from the Wingecarribee system was reanalysed. The purpose was to determine whether, for the raw water transfer option, there may be a risk of more frequent water treatment challenges or failures occurring at Goulburn, as compared to the present.

As a screening assessment, the Goulburn system raw and treated water data for turbidity and colour were examined. The rationale adopted when reviewing this data was to examine:

- whether the Goulburn WTP has produced treated water with elevated turbidity, and if so, what raw water turbidity levels may be associated with these elevations. This information was then compared to the turbidity levels recorded in the Wingecarribee source water; and
- whether the Goulburn WTP has produced treated water with elevated DOC levels (indicated by increased true colour measurements), and if so, what raw water DOC concentrations may be associated with these elevations. This information was then compared to the DOC levels recorded in the Wingecarribee source water.

5.1.3 Assessment 3: Reliability of Wingecarribee WTP

This assessment involved reviewing the current treatment capability (*i.e.* the 'typically achieved' removal of water quality contaminants) and the reliability (by considering the frequency of treatment 'failures' or occurrences of sub-optimal treatment) of the Wingecarribee WTP. These were considered by searching the raw and treated water quality data from Wingecarribee and looking for periods where there has been deterioration in raw, treated or both water qualities.

As a screening assessment, the Wingecarribee system raw and treated water data for turbidity and colour were examined. The aim of this assessment was to examine whether Wingecarribee WTP may experience suboptimal treatment or treatment 'failure' events that would result, under the treated water transfer option, in water of a less desirable quality being transferred to Goulburn as compared to what Goulburn receives from its present sources.

5.1.4 Assessment 4: Comparison of treated water quality at Goulburn and Wingecarribee

This assessment involved reviewing raw and treated water quality data from the Goulburn and Wingecarribee systems. The purpose was to compare the quality of the water currently being supplied to Goulburn against the quality that may be provided under either water transfer option. Some of the potential impacts that may arise when introducing different treated water to the Goulburn distribution network may include:

- taste and odour issues due to an increased presence of cyanobacteria;
- a change in THM formation potential (which can be linked to different DOC content in the water that is being chlorinated at Goulburn);
- taste issues brought about by blending of waters with different ionic composition;

- blending of waters with different hardness and pH characteristics (potentially impacting on taste and corrosivity in the Goulburn piped network).

The following time-series of water quality data were useful to assess the extent of these and other possible impacts:

- total and toxic cyanobacterial counts in Goulburn and Wingecarribee raw waters;
- true colour and DOC for raw water and true colour for treated waters at Wingecarribee and Goulburn;
- TDS concentrations recorded at Wingecarribee and Goulburn WTP outlets;
- hardness levels recorded at Wingecarribee WTP outlet and at Wingecarribee customer taps;
- hardness levels recorded at Goulburn WTP outlet and at Goulburn customer taps;
- pH recorded at Wingecarribee WTP outlet and at Wingecarribee customer taps;
- pH recorded at Goulburn WTP outlet and at Goulburn customer taps, and;

The rationale adopted when reviewing these data was to examine:

- whether algal / cyanobacterial counts (that can cause taste and odour issues as well as the release of toxins) in the Wingecarribee raw water would be adequately treated by the Goulburn WTP;
- whether DOC concentrations recorded in Wingecarribee raw water and/or THM levels in Wingecarribee treated water (compared to equivalent data recorded for the Goulburn system) may indicate that there will be a change in the THM formation potential, in the event that Goulburn is supplied with treated water from Wingecarribee WTP;
- TDS measurements and trends for treated water from Wingecarribee and Goulburn WTPs. A significant difference in TDS may mean that Goulburn would be supplied with water of different taste and other characteristics;
- hardness and pH trends for treated water from Wingecarribee and Goulburn WTPs. Differences may mean that Goulburn residents would be supplied with less stable and more corrosive water.

5.1.5 Assessment 5: Water quality changes that may occur during pipeline transfers

This assessment aimed to identify potential water quality impacts or transformations that may arise during the transfer of the water through the proposed 83 km pipeline. Some potential water quality impacts that can arise during the water transfers can include:

- biofilm growth (higher manganese, iron and algae levels in water travelling through the pipeline can promote biofilm growth) and sloughing of the biofilm, resulting in turbid water;
- anaerobic conditions developing following stagnant periods (*i.e.* water sits in the pipeline for long periods between uses) leading to taste and odour problems;
- ingress of contaminants into the pipeline through cracks or imperfections. This can result in increased particle counts in the water supply system. This may also lead to the presence of microbes (*e.g. E. coli*) in the water being piped, particularly if chlorine residuals have decayed during the transfer. Knowing the landuse practices in the vicinity of the pipeline aided the identification of contaminants that may enter the pipeline this way.

5.2 Potential water quality benefits

Managed appropriately, the operation of the Project would offer some opportunity for potential benefits to Goulburn's drinking water quality. For example:

- The lower and more stable turbidity, TDS and hardness of the Wingecarribee raw water as compared to Goulburn's present supply provides an opportunity to design a beneficial raw water blending strategy (if the raw water transfer option were adopted). The blending strategy may be able to be designed help protect the Goulburn WTP from challenges that have arisen in the past from the observed step changes or spikes in these raw water characteristics;
- Under either transfer option scenario, it would be likely that Goulburn would receive water that has less corrosive tendencies and was more chemically stable; and
- The additional water source would provide some redundancy in supply in the event, for example, that either the Wingecarribee or Goulburn raw waters were impacted by an algae bloom or other contamination event.

5.3 Risk assessment

5.3.1 Description

The Project would have impacts on the drinking water quality that may provide both benefits to the water supply in Goulburn as well as introducing new risks that would require careful management. A detailed assessment of the identified impacts was undertaken by considering the risks that would be associated with the impacts.

The risk assessment was conducted to:

1. prioritise the identified impacts in terms of the potential relative risk each may pose to the drinking water quality and the consequences that may arise from any changes; and
2. identify targeted actions and initiatives that would need to be adopted to monitor and manage the risks during the proposed Project operations.

A qualitative risk assessment approach was used. The relative risk for each identified impact was determined as a function of the likelihood of a certain impact event occurring as well as the consequences that may be associated with it. Initially the risk was assessed on the basis of the Project description, the water quality data and system understanding (*i.e.* how the current systems operate, the controls that already exist to manage some of the risks *etc.*) provided in this report. For the impacts with the higher relative risk scores, additional management and control activities have been identified for consideration, and the risks were reassessed assuming that these controls/actions would have been implemented. The impact mitigation measures described in Section 6.2 are basically an overarching description of these additional identified management activities and controls.

5.3.2 Outcomes

The details and outcomes of the risk assessment are provided in Appendix A. Broadly, the issues that would be a priority for management during the Project operation phase would be:

- For the raw water transfer option -

- sudden changes in the raw water characteristics (*e.g.* if switching completely from the present Goulburn waters to the Wingecarribee Reservoir water) feeding the Goulburn WTP that could shock the plant and result in sub-optimal treatment;
- higher counts of blue-green algae in the Wingecarribee Reservoir water as compared to the Goulburn waters, and the requirement for adequate water treatment at the Goulburn WTP;
- controlling the development of biofilm on the walls of the proposed 83 km pipeline, as the manganese and algae levels present in the raw water would possibly provide favourable conditions for this.

- For the treated water transfer option -
  - the delivery of water to Goulburn residents with different (significantly lower) concentrations of dissolved solids and hardness, that would likely result in differences in taste and aesthetics of the water supply;
  - the loss of chlorine residual along the pipeline and the need to maintain it to provide protection from post-treatment microbial contamination events;
  - the potential for contaminants to ingress the pipeline during non-operating periods (*i.e.* a pressure inversion event) through cracks, bursts or imperfection in the proposed pipeline and no additional point of treatment downstream of the Wingecarribee WTP;
  - water with elevated pH (> 9) being transferred to the Goulburn reticulation system. This could be exacerbated by interaction of the treated water with the wall of a DICL pipeline, resulting in further pH rise during the transfer;
  - the potential for water that has been sub-optimally treated at the Wingecarribee WTP and carrying hazardous concentrations of contaminants or microbes being provided to the Goulburn reticulation system.

The operational phase of the Project would also impact and introduce some new risks to the quality of Goulburn's drinking water supply. These new risks would not be beyond what could reasonably be expected from a surface water supply system in other parts of Australia, and would be manageable. The Wingecarribee Reservoir is already a well utilised drinking water source reservoir. The key activities that would need to be undertaken to manage the water quality are described below (Section 6.2).

6. Conclusion

6.1 Potential benefits and manageable risks

The Project would have impacts on the drinking water quality that would provide both benefits to the quality of the water supply in Goulburn as well as introducing new risks that would require careful management.

Managed appropriately, the operation of the Project would offer some potential benefits to Goulburn's drinking water quality. For example:

- the lower and more stable turbidity, TDS and hardness of the Wingecarribee raw water as compared to Goulburn's present supply provides an opportunity to design a beneficial raw water blending strategy (if the raw water transfer option were adopted). The blending strategy may be able to be designed help protect the Goulburn WTP from challenges that have arisen in the past from the observed step changes or spikes in these raw water characteristics, and may result in less acid dosing at the Goulburn WTP;
- under either transfer option scenario, it would be likely that Goulburn would receive water that has lower hardness and less corrosive tendencies than at present; and
- the additional water source would provide some redundancy in supply in the event, for example, that either the Wingecarribee or Goulburn raw waters were impacted by an algae bloom or other contamination event.

The primary risks that require management in any water supply are those to human health posed by pathogenic micro-organisms that may be present in the water. It is not likely that the Project would result directly in unmanageable health risks to Goulburn residents, as:

- the Wingecarribee Reservoir is already used as a drinking water source, and the Wingecarribee WTP has a history of managing the drinking water quality to meet *ADWG* microbial guideline values. Additionally, overall the Goulburn WTP has more barriers to the progression of pathogens than does the Wingecarribee WTP. The Goulburn WTP has a PAC dosing facility (to manage blue-green algae events) and an additional UV microbial disinfection step that is effective against all pathogen types (including protozoa) in comparison to the Wingecarribee WTP; and
- used strategically, the additional water source would offer a way to manage identified health risks, as water supply to Goulburn would be able to continue if either the existing or the proposed new water sources were impacted by an identified algae bloom or other contamination event (provided that the contamination were confined to one source or the other).

However the operational phase of the Project would impact and introduce some new risks to the quality of Goulburn's drinking water supply. These new risks would not be beyond what could reasonably be expected from a surface water supply system in other parts of Australia, and would be manageable. The Wingecarribee Reservoir is already a well utilised drinking water source reservoir. The key activities that would need to be undertaken to manage the water quality are described below (Section 6.2).

6.2 Impact mitigation

6.2.1 Under any operating scenario

The overarching recommendation would be to develop a plan for the management of water quality delivered by the proposed pipeline. A Hazard Analysis and Critical Control Point (HACCP) plan would be suitable format to document how the operation and monitoring of the water quality in the proposed pipeline would be undertaken. This HACCP plan would be incorporated into GMC's existing drinking water quality management plan. The design and implementation of these activities would be done in accordance with the *Australian Drinking Water Guidelines.*

The most effective way to manage risks (in addition to water quality management activities that are already undertaken) would be to strategically monitor the quality of the water in the Wingecarribee Reservoir and the proposed pipeline, and to cease supply where the results indicate that the water was not of a desirable quality. A strategic monitoring plan can be designed using the principles set out in *Strategic Water Quality Monitoring for Drinking Water Safety* (Rizak & Hrudey, 2007).

As a minimum, the monitoring and response plan would:

- address the key water quality indicators (for this system) of turbidity, hardness, TDS, *E. coli* and total/toxic cyanobacteria;
- describe critical limits[3] for the observed concentrations of the water quality indicators being monitored;
- outline actions that would be taken to manage the associated drinking water quality risks in the event that monitoring results have shown that a critical limit had been exceeded;
- describe the communications and data sharing protocols that would be necessary between WSC and GMC to ensure that water that would pose a public health risk to Goulburn residents was not transferred along the pipeline; and
- complement NSW Health's requirements for drinking water quality management and become a component of GMC's existing drinking water quality management plans and activities.

Additionally, under any operating scenario, an operating strategy would be developed that would optimise the mixing and dilution of the new with the existing water resources serving Goulburn, to minimise abrupt changes in the aesthetic nature of the water supply being provided to Goulburn.

6.2.2 Raw water transfer option

Risks that may arise in association with the impacts on drinking water quality under this water transfer scenario would be managed conceptually by:

- developing a blue-green algae monitoring, assessment and management protocol to manage the delivery of Wingecarribee Reservoir water. The most effective strategy that GMC could implement would involve monitoring and ceasing supply during critical bloom events in the Wingecarribee

[3] A critical limit can be considered to be the upper or lower limit for a water quality indicator that, if exceeded or not met, would imply that the treated drinking water quality would pose an unacceptable risk to water consumers or infrastructure. A water quality management plan should outline how these critical limits were derived, how they are monitored, and what actions would be undertaken to manage risk in the event that the limit was not met.

Reservoir. This plan would be derived in accordance with the *Interim Blue-Green Algae Management Protocols* (Water Directorate, 2009) and the *ADWG*;

- developing a water delivery and blending strategy that would limit rapid or step changes in the characteristics of raw water (*e.g.* TDS, alkalinity, hardness) feeding the Goulburn WTP, noting that a continuous operation strategy (rather than intermittent) and delivery/blending of water in Rossi Weir would best achieve this;
- developing a pipeline flushing/maintenance programme to ensure that, following a period of non-operation, the "first flush" of stagnant water would not be delivered to the Goulburn water supply system;
- In the preliminary years of operation, monitor the pipeline for biofilm development (and impacts on the hydraulics of the pipeline). If biofilms were occurring, it would be necessary to develop a maintenance (*e.g.* pipeline pigging) or investigation schedule to manage the biofilm.

6.2.3 Treated water transfer option

Risks that may arise in association with the impacts on drinking water quality under this water transfer scenario would be managed by:

- development of a delivery and blending strategy that minimises the changes in the aesthetic nature (particularly taste) of the water being delivered to Goulburn residents, noting that a continuous (rather than intermittent) operating strategy would best be able to achieve this;
- implementation of booster chlorinators along the proposed pipeline route to maintain desirable chlorine residual concentrations during transfers to the Goulburn reticulation, and also to limit biofilm growth in the pipeline. Note that disinfection is of paramount importance in controlling microbial quality. Particular attention should be paid to the following points:
  - operational factors affecting microbial quality (*e.g.* pH, disinfectant residual and turbidity) should be monitored frequently (daily or preferably continuously);
  - a minimum total chlorine residual should be present (0.5 mg/L after 30 minutes);
  - turbidity should be low (preferably < 1 NTU);
  - the pH should be optimised to suit the disinfectant used (subject to the need to minimise corrosion);
  - if the water temperature rises to more than 30°C for periods greater than a month (say, during the summer), the water should be monitored for amoebae;
  - the pipeline system would be adequately maintained;
  - the levels of disinfectant residual in the pipeline would be monitored frequently.

  In the longer term, WSC and GMC may jointly investigate the feasibility of installing a new pre-oxidation treatment step at the Wingecarribee WTP to further remove iron and manganese. This would reduce the risks posed by manganese to the WSC water customers, and further reduce biofilm growth potential in the proposed new pipeline;
- undertaking regular pipeline inspections/tests to determine the possibility of ingress by contaminants to the pipeline through cracks or construction imperfections (particularly as there would be no treatment downstream of the proposed pipeline). A positive pressure should be maintained in the pipeline at all times to prevent pressure inversions and contamination from adjacent soils;

- developing a pipeline flushing/maintenance programme to ensure that, following a period of non-operation, the “first flush” of stagnant water would not be delivered to the Goulburn water supply system.

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Appendix A

Risk Assessment

Consequence Guidance Table

Aspect	Insignificant	Minor	Moderate	Major	Catastrophic
Water quality compliance	Applicable water quality standards met across the region	Isolated exceedance water quality standards that is short lived	Exceedance of applicable air quality, noise or water quality standards in a local area	Long-term exceedance of applicable water quality standards in a number of local areas	Widespread exceedance of applicable water quality standards across the region
Socio-economic: Economic impacts on businesses and community	Loss of annual revenue less than $100 000	Loss of annual revenue less $1M but greater than $100 000	Loss of revenues less than $10M but greater than $1M	Loss of revenues less than $100 M but greater than $10 M	Loss of revenue greater than $100 M
Health and safety	Minor injury or illness to an individual – no treatment required	Minor injury or illness to 1 to 10 individuals in localised area – first aid required	Minor injury or illness to between 10 to 100 individuals – no treatment required, some over the counter medication required for some cases	Injury or illness to between 1 and 10 individuals – hospitalisation or medication required; all cases recoverable	One fatality or permanent disability

Likelihood Guidance Table

Likelihood	Description
Almost Certain	The event is expected to occur in most circumstances
Likely	The event will probably occur in most circumstances
Possible	The event could occur
Unlikely	The event could occur but not expected
Rare	The event occurs only in exceptional circumstances

Risk Matrix

Likelihood Level	Consequence Level				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	Low	Medium	High	Extreme	Extreme
Likely	Low	Medium	High	High	Extreme
Possible	Negligible	Low	Medium	High	High
Unlikely	Negligible	Low	Medium	Medium	High
Rare	Negligible	Negligible	Low	Medium	Medium

Risk Register

Risk Pathway	Consequence (IMPACT)	Existing/Project Controls	Consequence	Likelihood	Relative Risk	Additional Controls/Comments	Consequence	Likelihood	Treated Risk
RAW WATER TRANSFER OPTION									
Transfer of Wingecarribee Reservoir water directly to the Goulburn WTP (no blending with Goulburn water). The pipeline is being operated intermittently, resulting in a step change reduction of raw water characteristics: hardness, TDS, DOC. Note that turbidity of the feed water may not change as markedly (based on observed data). The Wingecarribee water contains high loads of blue-green algae.	The Goulburn WTP does not adequately handle the change in raw water characteristics and performs sub-optimally. Blue-green algae and toxins passes through the WTP and into the distribution system, posing a significant health risk to water users. NB: Toxic cyanobacteria counts in Wingecarribee have been observed at up to 40000 cells/mL	PAC dosing at Goulburn WTP (to handle algae)	Major	Likely	High	Develop raw water blending (Goulburn and Wingecarribee) and operation strategy that would minimise rapid changes in raw water characteristics feeding into Goulburn WTP. For the management of these risks it would be preferable to operate the pipeline continuously, rather than intermittently. Implement an algae monitoring and reaction program for the pipeline water quality (this would require cooperation between SCA, WSC and GMC for data sharing and information transfer) in accordance with *ADWG* guidance. Selective abstraction from the Wingecarribee Reservoir should be adopted - set limits for observed blue-green algae levels in the reservoir that would result in a cease of supply from that source.	Major	Possible	High
Transfer of Wingecarribee Reservoir water directly to the Goulburn WTP (no blending with Goulburn water). The pipeline is being operated intermittently, resulting in a step change reduction of raw water characteristics: hardness, TDS, DOC.	Sub-optimal treatment results in water being delivered to Goulburn that does not meet turbidity criteria for adequate disinfection. Turbidity > 5 NTU in treated water. Inadequate disinfection is provided at Goulburn WTP, resulting in *E. coli* or *Total Coliform* detections in the Goulburn distribution system	-	Moderate	Likely	High	Develop raw water blending (Goulburn and Wingecarribee) and operation strategy that would minimise rapid changes in raw water characteristics feeding into Goulburn WTP. For the management of these risks it would be preferable to operate the pipeline continuously, rather than intermittently.	Moderate	Unlikely	Medium
Transfer of Wingecarribee Reservoir water directly to the Goulburn WTP (no blending with Goulburn water). The pipeline is being operated intermittently, resulting in a step change reduction of raw water characteristics: hardness, TDS, DOC. Note that turbidity of the feed water may not change as markedly (based on observed data).	Organic content not adequately removed during treatment, can increase risk of THM formation following chlorination	-	Minor	Likely	Medium	Develop raw water blending (Goulburn and Wingecarribee) and operation strategy that would minimise rapid changes in raw water characteristics feeding into Goulburn WTP. For the management of these risks it would be preferable to operate the pipeline continuously, rather than intermittently.	Minor	Possible	Low

Risk Pathway	Consequence (IMPACT)	Existing/Project Controls	Consequence	Likelihood	Relative Risk	Additional Controls/Comments	Consequence	Likelihood	Treated Risk
Transfer of Wingecarribee Reservoir water directly to the Goulburn WTP (no blending with Goulburn water). The pipeline is being operated intermittently, resulting in a step change reduction of raw water characteristics: hardness, TDS, DOC.	Sub-optimal treatment results in water being delivered to Goulburn that does not meet aesthetic criteria (turbidity or colour). Turbidity of treated water 1-3 NTU	GMC's current drinking water quality and treatment management protocols (turbidity is measured online at the WTP)	Minor	Possible	Low	Develop raw water blending (Goulburn and Wingecarribee) and operation strategy that would minimise rapid changes in raw water characteristics feeding into Goulburn WTP. For the management of these risks it would be preferable to operate the pipeline continuously, rather than intermittently. NB: The blending strategy may have some benefits as compared to the present situation, as the lower TDS/alkalinity water from Wingecarribee may be able to be used strategically in a blend with Goulburn's present raw water supply to mitigate "spikes" of these characteristics seen in the water in Goulburn's dams	Insignificant	Possible	Negligible
Transfer of Wingecarribee Reservoir water directly to the Goulburn WTP (no blending with Goulburn water). The pipeline is being operated intermittently, resulting in a step change reduction of raw water characteristics: hardness, TDS, DOC.	Change in hardness, TDS, alkalinity of treated water being distributed to Goulburn. Noticeable change in taste and scaling characteristics of the water	-	Minor	Possible	Low	Develop raw water blending (Goulburn and Wingecarribee) and operation strategy that would minimise rapid changes in raw water characteristics feeding into Goulburn WTP. For the management of these risks it would be preferable to operate the pipeline continuously, rather than intermittently.	Insignificant	Possible	Negligible
Transfer of Wingecarribee Reservoir water to Goulburn storages, blending with existing Goulburn supply. The Goulburn WTP processes (dosing, *etc.*) are being managed well and treatment is optimised. The Wingecarribee Reservoir water contains pathogens (*e.g.* viruses, *Cryptosporidium*)	Microbial risk to the health of drinking water customers due to pathogens that were in the Wingecarribee supply	Goulburn WTP has multiple barrier treatment processes in place: DAF, filtration, chlorination and UV disinfection. Goulburn WTP has a good record of managing microbial risks. The Wingecarribee Reservoir is a better protected, less impacted catchment than the current Goulburn (Wollondilly River) catchment, and so may contain lesser concentrations of microbes - data would be needed to confirm this. The Wingecarribee WTP has adequately managed microbial risks in the past and has less disinfection barriers than Goulburn WTP.	Minor	Unlikely	Low	-	Minor	Unlikely	Low

Risk Pathway	Consequence (IMPACT)	Existing/Project Controls	Consequence	Likelihood	Relative Risk	Additional Controls/Comments	Consequence	Likelihood	Treated Risk
Transfer of Wingecarribee Reservoir water to Goulburn storages, blending with existing Goulburn supply. The Goulburn WTP processes (dosing, *etc.*) are being managed well and treatment is optimised. The Wingecarribee Reservoir water contains pathogens (*e.g.* viruses, *Cryptosporidium*), due to ingress through a pipe crack or imperfection during a period of non-use.	Microbial risk to the health of drinking water customers due to pathogens that have entered the pipeline through a crack or imperfection	The pipeline joins would be rubber ring jointed and would be constructed to relevant Australian Standards. Dilution of the ingress with pipeline water.	Minor	Possible	Low	Pipeline maintenance activities would identify whether there were any major leaks/cracks in the pipeline	Minor	Possible	Low
Transfer of Wingecarribee Reservoir water to Goulburn storages, blending with existing Goulburn supply. The Goulburn WTP processes (dosing, *etc.*) are being managed well and treatment is optimised. The Wingecarribee Reservoir water contains blue-green algae at levels up to those observed in recent summer blooms	Health risk to drinking water customers from the presence of the algae in the supply	Goulburn WTP has multiple barrier treatment processes in place: DAF, filtration, chlorination and UV disinfection, and PAC dosing. The Wingecarribee WTP has adequately managed algae risks in the past and has fewer barriers to contamination progression than those present at the Goulburn WTP.	Moderate	Possible	Medium	Implement an algae monitoring and reaction program for the pipeline water quality (this would require cooperation between SCA, WSC and GMC for data sharing and information transfer) in accordance with *ADWG* guidance. Selective abstraction from the Wingecarribee Reservoir should be adopted - set limits for observed blue-green algae levels in the reservoir that would result in a cease of supply from that source.	Minor	Possible	Low
Transfer of Wingecarribee Reservoir water to Goulburn storages, blending with existing Goulburn supply. The Goulburn WTP processes (dosing, *etc.*) are being managed well and treatment is optimised. Biofilms have grown in the pipeline over time, due to manganese, iron, and algae interactions in the raw water being transferred. The pipeline is being operated at capacity.	Sloughing of the biofilm, resulting in more turbid water being supplied to the Goulburn WTP	None for the biofilm growth aspect. The Goulburn WTP would likely be able to handle the biofilm turbidity (minor increase in turbidity)	Minor	Likely	Medium	Provide chlorination along the 83km pipeline to address biofilm growth in pipes, and/or pre-oxidation step such as $KMnO_4$ dosing of the water prior to entry to pipe (requires investigation)	Insignificant	Likely	Low

Risk Pathway	Consequence (IMPACT)	Existing/Project Controls	Consequence	Likelihood	Relative Risk	Additional Controls/Comments	Consequence	Likelihood	Treated Risk
The pipeline runs adjacent to fields that are irrigated with treated wastewater effluent, near Governor's Hill. Pipeline cracks emerge, there's a pressure inversion, and treated effluent seeps into the pipeline	Health risks from the presence of microbes in the treated effluent entering the pipeline and Goulburn's disinfection network	The pipeline would be under high pressure in the vicinity of the irrigated pastures; residual chlorine disinfection Goulburn WTP Construct pipelines to relevant Australian Standards	Major	Unlikely	Medium	Place pressure loggers in the pipeline in the vicinity of the irrigated pastures. Cease supply following any pressure inversion event and investigate/monitor water quality for microbes.	Major	Rare	Medium
Transfer of Wingecarribee Reservoir water to Goulburn storages, blending with existing Goulburn supply. The Goulburn WTP processes (dosing, *etc*.) are being managed well and treatment is optimised. Biofilms have grown in the pipeline over time, due to manganese, iron, and algae interactions in the raw water being transferred. The pipeline is being operated at capacity.	Biofilm growth has hindered the hydraulic capability of the pipeline - Goulburn cannot be provided with water at the design flow rates, and the town is in need of the full capacity transfer.	None for the biofilm growth aspect. Goulburn has an existing water supply	Moderate	Possible	Medium	Provide chlorination along the 83km pipeline to address biofilm growth in pipes, and/or pre-oxidation step such as $KMnO_4$ dosing of the water prior to entry to pipe (requires investigation)	Minor	Possible	Low
TREATED WATER TRANSFER OPTION									
Transfer of water from the Wingecarribee WTP to the Goulburn reticulation system. The Wingecarribee WTP is performing nominally.	The new water source provides water with greater turbidity into the Goulburn WTP, encroaching on *ADWG* aesthetic limits and limits for adequate disinfection. Following sampling of the water supply, NSW Health issues a non-compliance notice to GMC. Inadequate disinfection is achieved, loss of protection against ingress events.	Wingecarribee WTP usually achieves water < 1 NTU, though there have been observed spikes > 5 NTU.	Moderate	Possible	Medium	Monitor treated water at Wingecarribee WTP, cease supply to Goulburn if turbidity > 4 NTU	Insignificant	Possible	Negligible
Transfer of water from the Wingecarribee WTP to the Goulburn reticulation system. The Wingecarribee WTP is performing nominally.	True colour and organic content in treated water from Wingecarribee WTP is > existing Goulburn supply. An increased THM formation potential can be associated with this.	Wingecarribee WTP usually achieves treated water with a true colour (and so perhaps organic content) < Goulburn WTP	Insignificant	Rare	Negligible	-	Insignificant	Rare	Negligible

Risk Pathway	Consequence (IMPACT)	Existing/Project Controls	Consequence	Likelihood	Relative Risk	Additional Controls/Comments	Consequence	Likelihood	Treated Risk
Transfer of water from the Wingecarribee WTP to the Goulburn reticulation system. The Wingecarribee WTP is performing nominally.	Differences in alkalinity, hardness, TDS in the water supplied to Goulburn taps. Customers notice a difference in taste and complain to GMC	-	Minor	Almost Certain	Medium	Customer education about the benefits of the proposed pipeline scheme and the need for some adjustment	Minor	Almost Certain	Medium
Transfer of water from the Wingecarribee WTP to the Goulburn reticulation system. The Wingecarribee WTP is performing nominally.	Differences in alkalinity, hardness, TDS in the water supplied to Goulburn taps. Corrosivity potential increases.	The Wingecarribee treated water is likely to be more stable and less corrosive than Goulburn's current supply	Insignificant	Unlikely	Negligible	-	Insignificant	Unlikely	Negligible
Transfer of water from the Wingecarribee WTP to the Goulburn reticulation system. The Wingecarribee WTP is performing nominally.	Presence of *E. coli* and also pathogenic microorganisms in the treated water from Wingecarribee. A significant decay in chlorine residual over the length of the pipeline occurs during transfer (total loss). The chlorine residual doesn't provide adequate disinfection of microbes, posing a health risk to customers in Goulburn.	The Wingecarribee WTP has historically provided water that has met *ADWG* for microbial content. The Wingecarribee Reservoir has a less impacted catchment than the present Goulburn water supply.	Moderate	Unlikely	Medium	Provide booster chlorination along the pipeline to maintain chlorine residual. WSC to monitor microbial indicators at the treatment plant outlet and inform GMC in the event that *E. coli* or other indicators were detected	Minor	Unlikely	Low
Transfer of water from the Wingecarribee WTP to the Goulburn reticulation system. The Wingecarribee WTP is performing nominally.	Presence of *E. coli* and also *Total Coliforms* in the treated water from Wingecarribee. A significant decay in chlorine residual over the length of the pipeline occurs during transfer (total loss). The chlorine residual doesn't provide adequate disinfection of microbes, allowing for *Coliform* regrowth in the pipeline to detectable levels. NSW Health monitoring detects coliforms and issues GMC with a notice and an investigation order.	The Wingecarribee WTP has historically provided water that has met *ADWG* for microbial content.	Minor	Possible	Low	Provide booster chlorination along the pipeline to maintain chlorine residual. WSC to monitor microbial indicators at the treatment plant outlet and inform GMC in the event that *E. coli* or other indicators were detected	Insignificant	Possible	Negligible

Risk Pathway	Consequence (IMPACT)	Existing/Project Controls	Consequence	Likelihood	Relative Risk	Additional Controls/Comments	Consequence	Likelihood	Treated Risk
Transfer of water from the Wingecarribee WTP to the Goulburn reticulation system. The Wingecarribee WTP is performing nominally.	Wingecarribee WTP unable to remove cyanobacteria toxins from Wingecarribee raw water.	The Wingecarribee WTP has PAC facilities, and SCA has a comprehensive algae monitoring program. The Wingecarribee WTP has a history of being able to adequately handle the challenges associated with cyanobacteria and to be able to maintain supply during bloom periods in the summer.	Moderate	Likely	High	Implement an algae monitoring and reaction program for the pipeline water quality (this would require cooperation between SCA, WSC and GMC for data sharing and information transfer) in accordance with *ADWG* guidance. Selective abstraction from the Wingecarribee Reservoir should be adopted - set limits for observed blue-green algae levels in the reservoir that would result in a cease of supply from that source.	Moderate	Possible	Medium
Transfer of water from the Wingecarribee WTP to the Goulburn reticulation system. The pipeline has not been operating for several months, stagnant water in the pipeline. The pipeline is turned on.	Goulburn residents receive water that has undergone anaerobic transformations, and has an undesirable taste/odour	-	Minor	Likely	Medium	Flush the pipeline regularly during non-operating periods and immediately prior to re-engaging the pipeline to serve Goulburn.	Minor	Possible	Low
Transfer of water from the Wingecarribee WTP to the Goulburn reticulation system. The Wingecarribee WTP processes (dosing, *etc.*) are being managed well and treatment is optimised. Biofilms have grown in the pipeline over time, due to manganese, iron, and algae interactions in the raw water being transferred. The pipeline is being operated at capacity.	Sloughing of the biofilm, resulting in more turbid water being supplied to the Goulburn residents	Wingecarribee WTP provides barrier to algae, manganese progression.	Insignificant	Likely	Low	Provide chlorination along the 83km pipeline to address biofilm growth in pipes, and/or pre-oxidation step such as $KMnO_4$ dosing of the water prior to entry to pipe (requires investigation)	Insignificant	Likely	Low
Transfer of water from the Wingecarribee WTP to the Goulburn reticulation system. The Wingecarribee WTP is performing nominally. The pH of the Wingecarribee WTP filtrate > 9	Water supplied to Goulburn does not meet pH requirements set out in *ADWG*	-	Minor	Almost certain	Medium	Develop blending strategy with Goulburn water for prior to delivery to reticulation system Investigate need for pH correction at Wingecarribee WTP	Insignificant	Almost certain	Low

Risk Pathway	Consequence (IMPACT)	Existing/Project Controls	Consequence	Likelihood	Relative Risk	Additional Controls/Comments	Consequence	Likelihood	Treated Risk
Transfer of water from the Wingecarribee WTP to the Goulburn reticulation system. The Wingecarribee WTP processes (dosing, *etc.*) are being managed well and treatment is optimised. Biofilms have grown in the pipeline over time, due to manganese, iron, and algae interactions in the raw water being transferred. The pipeline is being operated at capacity.	Biofilm growth has hindered the hydraulic capability of the pipeline - Goulburn cannot be provided with water at the design flow rates, and the town is in need of the full capacity transfer.	Wingecarribee WTP provides adequate barrier to algae, Mn progression. Goulburn has an existing water supply.	Insignificant	Likely	Low	Provide chlorination along the 83km pipeline to address biofilm growth in pipes, and/or pre-oxidation step such as $KMnO_4$ dosing of the water prior to entry to pipe (requires investigation)	Insignificant	Likely	Low
Transfer of water from the Wingecarribee WTP to the Goulburn reticulation system. The Wingecarribee WTP has experienced a period of sub-optimal treatment. Monitoring of the Wingecarribee filtered water is showing high turbidity that indicates that other contaminants may have also been inadequately removed.	Health risks associated with the passage and presence of microbes in the water; water does not meet *ADWG* for several contaminants and quality indicators	-	Major	Likely	High	WSC to monitor microbial indicators at the treatment plant outlet and inform GMC in the event that *E. coli* or other indicators were detected. Develop a HACCP plan that outlines how the Wingecarribee treated water would be controlled, monitored and what would happen when "critical" water quality indicator limits were exceeded (*e.g.* cease supply to Goulburn)	Major	Possible	High
The pipeline runs adjacent to fields that are irrigated with treated wastewater effluent, near Governor's Hill. Pipeline cracks emerge, there's a pressure inversion, and treated effluent seeps into the pipeline	Health risks from the presence of microbes in the treated effluent entering the pipeline and Goulburn's disinfection network	The pipeline would be under high pressure in the vicinity of the irrigated pastures; residual chlorine disinfection Construct pipelines to relevant Australian Standards	Catastrophic	Unlikely	Medium	Place pressure loggers in the pipeline in the vicinity of the irrigated pastures. Cease supply following any pressure inversion event and investigate/monitor water quality for microbes.	Catastrophic	Rare	Medium

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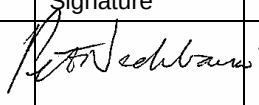
A	R Signor	P Nadebaum		J Earle		15 Jan 2010