9. Drinking water quality

This chapter summarises information from a Drinking Water Quality Assessment undertaken for the Project. A copy of the full assessment report is included in Appendix D.

9.1 Methodology

The objective of the drinking water quality assessment was to identify and examine 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).

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

- *Australian Drinking Water Guidelines* (NHMRC, 2004);
- *A Guide to Hazard Identification and Risk Assessment for Drinking Water Supplies* (Nadebaum *et al.*, 2004);
- *2007 Audit of the Sydney Drinking Water Catchment* (DECC, 2007a); and
- *Risk Assessment for Drinking Water Sources* (Miller *et al.*, 2009).

The focus of the impact assessment was to identify impacts that would possibly give rise to health risks that would breach the requirement of the *Public Health Act 1991*, and how these risks would be managed. Other impacts that could result in aesthetic changes to the quality of the water being supplied to Goulburn were also considered. The assessment considered impacts that would arise under either the raw or treated water transfer scenarios.

The key steps involved in preparing the drinking water quality assessment were to:

- **Understand the systems**. This involved:
  - Developing a description of the present water supply systems (from catchment -to-tap) for Goulburn and Wingecarribee, as well as the changes that would occur in association with the Project; and
  - Undertaking a targeted analysis of water quality data to observe trends in drinking water quality at each system.
- **Identify and assess risks to water quality**. 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.
- **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 Goulburn's supplied drinking water quality and the risks that may arise.

9.2 Existing environment

This section summarises the existing water supply systems at Goulburn and Wingecarribee, and the historical raw and treated drinking water quality at each system. Figure 9.1 describes the physical components of the drinking water supply systems, and how it is proposed that they may be connected.

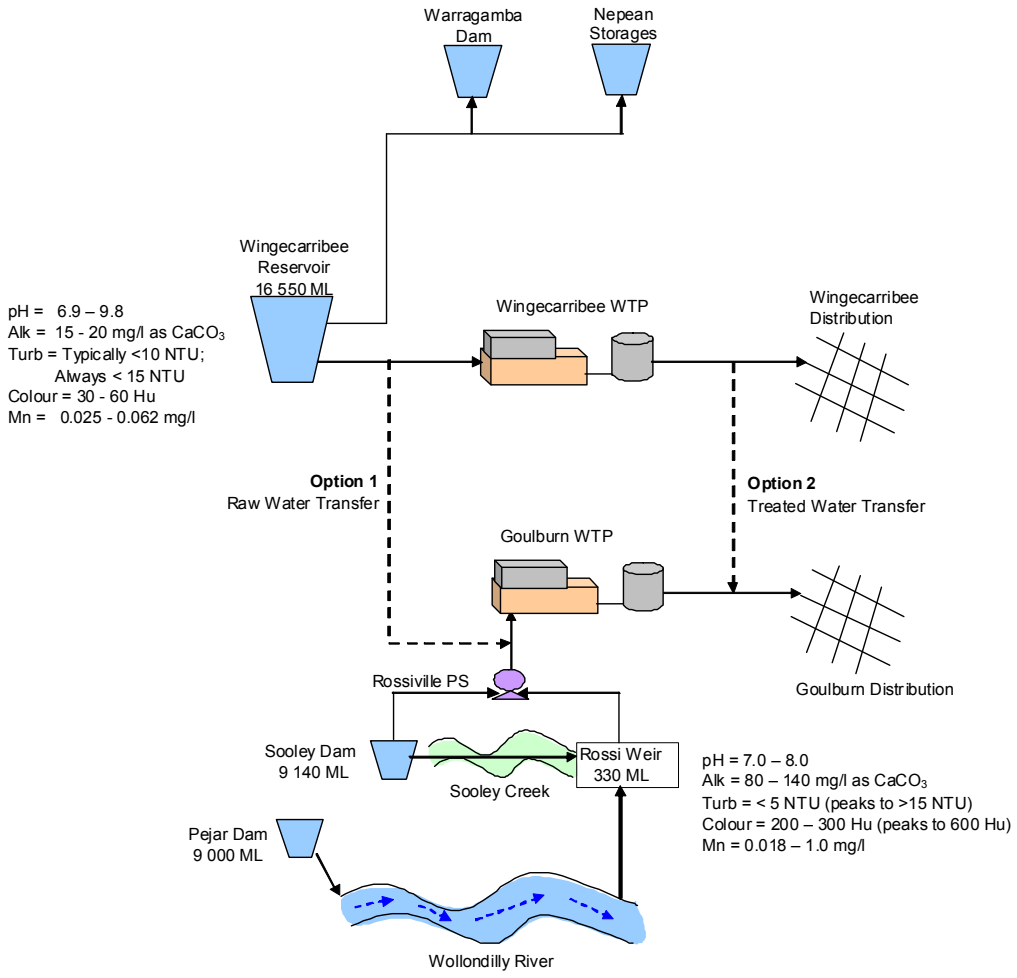

Figure 9.1 The Goulburn and Wingecarribee water supply systems, and the options for transferring water being considered as part of the Project

9.2.1 Goulburn water supply system

GMC is the local government body responsible for provision of a water supply to Goulburn.

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, 2009a).

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).

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, 2009a).

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.

The study recommended improvements at every stage in the treatment process chain, including replacement of the settling clarifier with a dissolved air flotation (DAF) clarification process and also refurbishment of the filtration process. Figure 9.2 provides an overview of the Goulburn and Wingecarribee WTP treatment process.

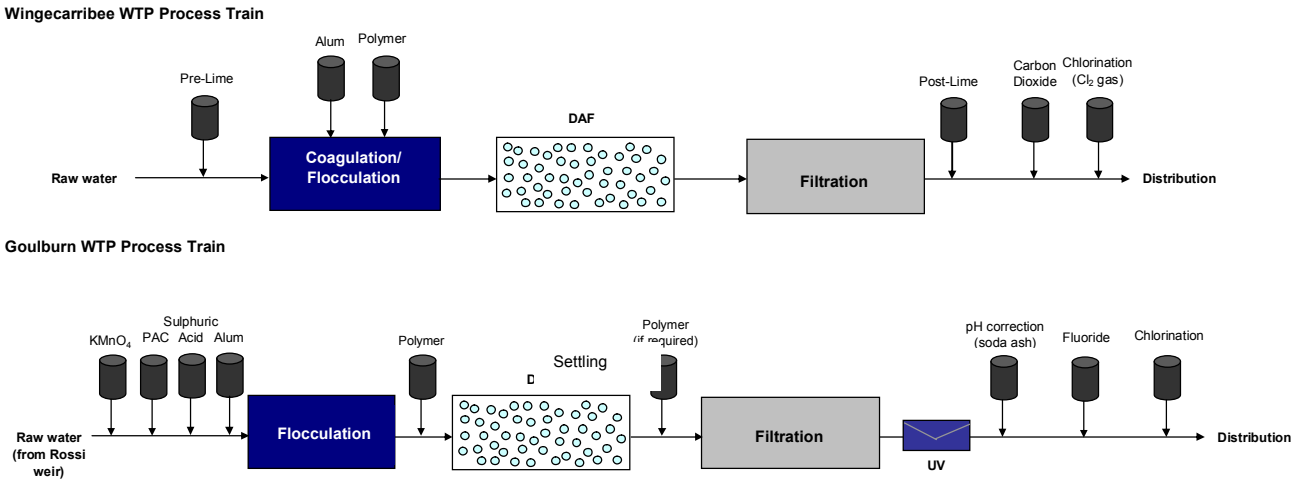

Figure 9.2 Goulburn and Wingecarribee WTP treatment processes

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:

- Potassium permanganate ($KMnO_4$) dosing;
- Powdered activated carbon (PAC);
- pH adjustment (sulphuric acid dosing);
- Coagulation / flocculation (dosing alum, flocculant aid, polymer);
- Dissolved air flotation (DAF) clarification;
- Multi-media sand filtration;
- Post-filtration pH correction (soda ash);
- Ultra-violet (UV) disinfection, and;
- Chlorination (Cl_2 gas).

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

9.2.2 Wingecarribee water supply system

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 SCA. The reservoir has a capacity of 25 900 ML and a small direct catchment area of 40 km^2. The catchment includes large tracts of mainly forested land and several nature reserves and the township of Robertson. 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 draws most of its water from the transfer scheme.

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. In addition to the transfer scheme water from the Wingecarribee Reservoir is distributed to Southern Highlands communities including Bowral, Mittagong and Moss Vale, after treatment at the Wingecarribee WTP. Surrounding the Wingecarribee Reservoir is a special area classification designating restricted entry. The reservoir is not open to the public for any recreational purposes.

Wingecarribee water treatment plant

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

- 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).

9.2.3 Removal of microbes by water treatment at each WTP

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[1] 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 9.1. Based on the information in Table 9.1 and the description of the treatment processes in Figure 9.2, the Goulburn WTP would typically provide an additional 4 $\log_{10}$ removal of protozoa and bacteria and 1-2 $\log_{10}$ removal of viruses compared to Wingecarribee WTP.

[1] A log reduction of 1 indicates a 90 percent removal of microbes, 2 indicates 99 per cent, 3 indicates 99.9 per cent, *etc.*

Table 9.1 Indicative log reductions from well operated validated treatment processes

Treatment process	Dose/Ct[a]	Log reductions		
		Virus	Bacteria	Protozoa
Coagulation, sedimentation and filtration	NA	1	1	3
DAF	NA	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

9.3 Impact assessment

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.

These targeted assessments were used to inform a drinking water quality risk assessment (as described in the full report at Appendix D). A summary of the results of the targeted assessment is provided below (in Table 9.2) and the outcomes from the data and risk assessments are elaborated on in Section 9.4.

Table 9.2 Summary of Drinking Water Quality at Goulburn and Wingecarribee

Parameter(s)	Raw Water		Treated Water		Comments (implications and potential impacts)
	Wingecarribee	Goulburn	Wingecarribee	Goulburn	
Turbidity	Typically < 10 NTU; always < 15 NTU	Typically < 5 NTU but variable and peaks to > 15 NTU	Filtered water < 1.5 NTU, but that water at outlet is slightly higher (generally < 0.6 NTU) as a result of lime dosing for pH correction	Generally < 1.5 NTU, even when challenged by higher raw water turbidity	*The ADWG recommends that treated water turbidity is < 1 NTU, to enable sufficient disinfection of the water to take place.* 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. 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 significantly.
E.coli	Often > 10 / 100 mL and spike up to 16 000 / 100 mL	No data were available	NSW Health monitoring indicates that these systems meet the *ADWG* requirement of 0 detected organisms in 98% of 100 mL samples.		*E. coli is commonly used as an indicator for the presence of microbial pathogens, though it has many limitations. The ADWG recommends that at least 98% of 100 mL samples from the reticulation system tests negative for the presence of E. coli.* 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

Parameter(s)	Raw Water		Treated Water		Comments (implications and potential impacts)
	Wingecarribee	Goulburn	Wingecarribee	Goulburn	
					the ADWG for Wingecarribee customers, and so these risk would be managed. 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, 2007a).
Manganese	0.025 - 0.062 mg/L	No data were available, however GMC has indicated that manganese control has been a challenge at the Goulburn WTP in recent years	< 0.01 – 0.040 mg/L (median *ca.* 0.025 mg/L)	No data were available	*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.* 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 transfer 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
True colour	Typically 30 - 60 Hu	Usually 200 – 300 Hu, but frequent peaks up to 600 Hu	< 3 Hu	< 10 Hu (median *ca.* 6 Hu)	*The ADWG recommends that true colour of treated water < 15 Hu for aesthetic purposes.* Under the raw water transfer option, Goulburn WTP would experience lower and less variability in raw water true colour, possibly contributing to it being operationally easier to treat. However, intermittent use of the pipeline could result in extremes of true colour in the 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

Parameter(s)	Raw Water		Treated Water		Comments (implications and potential impacts)
	Wingecarribee	Goulburn	Wingecarribee	Goulburn	
					difficulties linked to variable alkalinity and pH adjustment is a different matter as discussed elsewhere). 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.
DOC	5 mg/L	Typically 9 – 12 mg/L, concentrations have been measured at 18 mg/L	No data were available		*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.* 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, then there would likely be a lower risk of DBP formation in Goulburn's distribution system, as compared to the present situation. This would need to be verified.
pH	Variable between 6.9 – 9.8	Stable at values between 7.0 – 8.0	7.0 – 9.0	7.1 – 8.2	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

Parameter(s)	Raw Water		Treated Water		Comments (implications and potential impacts)
	Wingecarribee	Goulburn	Wingecarribee	Goulburn	
					blending takes place and also the pipeline operating strategy. 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 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.
Alkalinity	15 - 20 mg/L as $CaCO_3$	80 – 140 mg/L as $CaCO_3$	No data were available		*The ADWG recommends keeping Total Dissolved solids 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 would be 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). 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
Hardness	20 - 25 mg/L as $CaCO_3$	100 – 250 mg/L as $CaCO_3$			
TDS	Approx. 50 mg/L at surface; 160 mg/L at depth of 10 - 15 m	100 – 500 mg/L, with pronounced "step" changes in TDS being common, presumably due to changes in source			

Parameter(s)	Raw Water		Treated Water		Comments (implications and potential impacts)
	Wingecarribee	Goulburn	Wingecarribee	Goulburn	
					on the operating strategy for the pipeline.
Chlorine residual	No data were available				*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.* 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.
Cyanobacteria	Total cyanobacterial counts up to 622 000 cells/ mL; median *ca.* 100 000 cells/ mL	Total cyanobacterial counts up to 940 000 cells/mL, though generally < 600 000 cells /mL; median *ca.* 10 000 cells/m L	No data were available		For the raw water transfer option, 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. This would require a monitoring and communication plan to be set up between the water managers. 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.

9.4 Summary of results

9.4.1 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).

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 9.4.2).

9.4.2 Potential priorities for Goulburn's drinking water quality management

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 (if it were selected as the pipeline material), resulting in further pH rise during the transfer; and
  - The potential for water that has been sub-optimally treated at the Wingecarribee WTP and carrying hazardous concentrations of microbes or other contaminants being provided to the Goulburn reticulation system.

9.5 Mitigation measures

Under any operating scenario

- A Hazard Analysis and Critical Control Point (HACCP) plan would be developed 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 *ADWG; and*
- Develop a strategic monitoring plan using the principles set out in Strategic Water Quality Monitoring for Drinking Water Safety (Rizak & Hrudey, 2007) to 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.

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[2] 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.

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 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. This would include identifying receivers for the first flush water and determining the regularity and scheduling of this activity; and

[2] 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.

- 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.

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; and

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.