LOWER MANUHERIKIA VALLEY WATER RESOURCES STUDY

DRINKING-WATER SECURITY REVIEW

MANUHERIKIA IRRIGATION CO-OPERATIVE SOCIETY LTD

Lower Manuherikia Valley Water Resources Study

Drinking-water Security Review

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1 Summary

In response to an approach by the Manuherikia Irrigation Co-operative Society (MICS), the Central Otago District Council (CODC) agreed to jointly investigate the possibility of provision of domestic water for Alexandra and Clyde (including lifestyle blocks) from the proposed MICS irrigation supply. Opus International Consultants Ltd was asked by the MICS to investigate and report on the feasibility of this proposal, to a brief provided by the CODC, as an extension to its irrigation scheme feasibility study.

The MICS has a water take resource consent for 326 mega litres per day (MLD) from Lake Dunstan at Dairy Creek for irrigation and frost fighting. It is possible that some of this water could be used for drinking water supply for Alexandra and Clyde.

Opus has been requested to consider the following:

- Suitability of Lake Dunstan water as a source for town domestic supply.
- Treatment options required to ensure that the supply complies with the *Drinking Water Standards for New Zealand 2005 (Amended 2008)*.
- Estimates of the capital and ongoing operational costs for CODC regarding treatment and supply of potable water to Alexandra and Clyde.
- Issues and risks for CODC in adopting this supply for Alexandra and Clyde.

On the basis of water quality data that is available it has been determined that water from Lake Dunstan is suitable for supply as drinking water after treatment. There is no evidence that the water contains chemical contaminants which would be of public health concern, however the water has increased turbidity from time to time and there are discharges from community wastewater systems upstream of the abstraction point. For use as a drinking water supply, treatment would be required to remove particulate material, including protozoa and to disinfect the water for microbiological contaminants.

A preliminary assessment of the catchment indicates that to meet the requirements of the *Drinking Water Standards for New Zealand* (DWSNZ), treatment would need to provide protozoa removal of between 3 and 5-log. This cannot be confirmed until a detailed catchment assessment or protozoa monitoring is undertaken.

Conventional treatment and membrane filtration have been identified as the options that would provide the level of treatment required. It is considered that membrane filtration followed by UV disinfection with chlorination would be the most suitable option to provide 5-log protozoa removal. Membrane filtration with chlorination would be suitable if only 3-log or 4-log protozoa removal is required..

There are a number of ways in which the MICS resource consent can be utilised to provide drinking water for Alexandra and Clyde. The options for doing this will depend on decisions that MICS make regarding the supply of water for irrigation. Regardless of the

option chosen, it is likely to be necessary to vary the consent to allow for use of the water for drinking water supply.

Three scenarios have been developed for using MICS-consented water for water supply to Alexandra and Clyde. Scenario A would require the construction of a 26 MLD treatment plant at Clyde and provision of treated water to Clyde and to Alexandra via a 10 kilometre pipeline at a total cost of approximately $19M. Scenario B would require the construction of a 26 MLD treatment plant adjacent to a proposed irrigation storage reservoir at Muttontown and supply of treated water to both Clyde and Alexandra via pipelines at a total cost of approximately $16.5M. Scenario C would require the construction of treatment plants at Clyde at a cost of approximately $5M and Alexandra at a cost of approximately $9M.

The issues and risks for CODC in using water taken from Lake Dunstan under the MICS resource consent are associated with the need to have an ongoing and functional working relationship with MICS. While this is possible and could be effectively achieved, it could cause delays due to MICS gaining resource consents, making decisions about how best to utilise water for irrigation, raising capital or installing infrastructure.

The favoured option is scenario B because it has the lesser cost of the two single treatment plant options. The single treatment plant options have a considerable advantage of having significantly reduced operational costs and greater flexibility to provide water to lifestyle properties between Clyde and Alexandra. Scenario B would utilise water stored for irrigation and would require a mutually beneficial agreement with the MICS.

2 Introduction

In response to an approach by the MICS, the CODC agreed to jointly investigate the possibility of provision of domestic water for Alexandra and Clyde (including lifestyle blocks) from the proposed MICS irrigation supply. Opus International Consultants Ltd was asked by the MICS to investigate and report on the feasibility of this proposal, to a brief provided by the CODC, as an extension to its irrigation scheme feasibility study.

This drinking water security review presents the third component of a Water Resource feasibility study for the Lower Manuherikia Valley in Central Otago and its associated rural and community activities. The scope for the wider study was to examine the possibility of extending the proposed privately supported Dairy Creek Irrigation Scheme to incorporate a wider community water resources objective by combining the various irrigation and water supply schemes in the command area into a single entity with possibly a single source. This third study component examines the use of water abstracted from Lake Dunstan for potable water supply which complies with the DWSNZ.

In May 2003 water permit 2002.725 was issued to the MICS to abstract water from Lake Dunstan for irrigation and frost fighting. An extraction point identified at Dairy Creek, approximately 1km north of the Clyde Dam. The consent allows the abstraction from 1st August to 30th May annually of a maximum of 4.53 m^3 per second and a maximum of

326,160 m^3 per day. Approximately 2.0 m^3 per second is required by the proposed Dairy Creek Irrigation Scheme. After studying several options, it was proposed that the balance of 2.53 m^3 per second would be used for irrigation and potable water in the adjacent areas. The irrigation areas covered would be the proposed Dairy Creek Irrigation Scheme, the Manuherikia and Galloway Irrigation Schemes, and several areas identified to be irrigable in the Lower Manuherikia Valley, which extends from Lake Dunstan in the west to Tiger Hill in the east.

The communities considered for potable water supply are Alexandra, Clyde and rural lifestyle properties situated near to these communities.

To clarify the scope for this study component, Opus was briefed by Peter Morton of the CODC on the phone on Friday 26th June 2009. This phone discussion was followed by an email the same day. CODC is currently studying alternative options for the Alexandra water supply to overcome current community dissatisfaction with the quality of the existing supply. Although Clyde does not have the same water quality problems as Alexandra, it may be possible to combine both town water supplies into a single scheme.

Based on the brief given by CODC, this report considers the feasibility of providing domestic water for Alexandra and Clyde (including rural lifestyle blocks) from the proposed Lower Manuherikia Valley irrigation scheme supply. As agreed with CODC, this report does not cover any alternative options for water supply or propose recommendations to address the high water consumption in Alexandra.

In line with CODC's expectations, the report aims to address the following issues:

- Suitability of Lake Dunstan water as a source for town domestic supply.
- Treatment options required to ensure that the supply complies with the *Drinking Water Standards for New Zealand 2005 (Amended 2008)*
- Estimates of the capital and ongoing operational costs for CODC regarding treatment and supply of potable water to Alexandra and Clyde.
- Issues and risks for CODC in adopting this supply for Alexandra and Clyde.

Peter Morton of CODC has been advised that the consent to take water which will be used by the proposed irrigation scheme does not permit abstraction during June and July. CODC does not wish to operate an alternative source to cover that winter period.

3 Suitability of Water from Lake Dunstan for a Community Drinking-water Supply

The water in Lake Dunstan is supplied by the Clutha and Kawarau Rivers. The Clutha discharges into the head of the lake and the Kawarau discharges into the lake near

Cromwell. The Clutha and Kawarau Rivers drain from lakes Wanaka and Wakatipu respectively. Subsequently the catchment for Lake Dunstan is extensive.

The main water quality parameter that impacts the suitability of surface waters with regard to treatment for drinking water supply is turbidity. The total turbidity is a factor but perhaps more critical is the rate of change in turbidity as rapid changes in turbidity challenge treatment processes.

No turbidity data is available from the likely MICS abstraction point however data has been obtained from the Clutha River at Alexandra. The data was obtained from Contact Energy and NIWA by CODC for the purposes of water supply investigation. The data set (Appendix 1) includes almost daily turbidity readings from September 1995 to December 2008 with a total of 4631 readings. Analysis of the results is provided in Table 1 below.

A further dataset was obtained from Otago Regional Council (Appendix 2). This dataset includes 78 samples collected from Dead Mans Point in Lake Dunstan between July 1997 and June 2009. Dead Mans Point is located about half way down Lake Dunstan at the Cromwell Bridge. This point is upstream from the confluence of the Kawarau Arm of the Lake and the Clutha arm. Hence, any turbidity inputs from the Kawarau River do not affect samples taken from this location.

Table 1. Turbidity results Lake Dunstan and Clutha River at Alexandra

	Clutha River at Alexandra (N = 4631)	Lake Dunstan at Dead Mans Point (N = 78)
Minimum	0	0.3
Maximum	168	6.2
Mean	4	1.1

Eschericia coli (E. coli) is an organism that inhabits the intestines of all mammals. Though it is not a pathogen itself it is used as an indicator of faecal contamination. When *E. coli* is identified in water, it is assumed that faecal bacteria, viruses and protozoa, which could cause illness, are also present.

The Otago Regional Council dataset included 70 *E. coli* results, 42 pH field test results and 41 pH lab test results. The results are provided in Table 2 below.

Table 2. *E. coli* and pH results from Lake Dunstan. Dead Mans Point

	E. coli/100,ml (N = 70)	pH Field test (N = 30)	pH Lab test (N = 41)
Minimum	.05	7.5	7.3

Maximum	28	8.8	8.7
Mean	2.81	8.1	7.9

The turbidity data with a mean of 4 NTU at Alexandra from a data set of over 4000 samples taken over 13 years indicates that Lake Dunstan water has generally low turbidity for a surface water source. This is supported by the data from Dead Mans Point which has a mean of 1.1 NTU from 78 samples over 12 years. The maximum turbidity result of 168 NTU and 6.2 NTU respectively are also not excessively high for a surface water source. Some surface water sources in New Zealand have turbidity maximums which exceed 1000 NTU and they are able to meet the compliance requirements of the standards after treatment. The turbidity data suggest, however, that filtration of the water supply will be required to reduce the particulate material to an acceptable level before it would be suitable for use as a drinking water supply. The turbidity levels are well within the capability of a number of filtration technologies available.

The *E. coli* data is also less than what would be expected for a surface water supply of this type. The *E. coli* data has been collected from a location upstream of the confluence of the Kawarau River. While these results are not representative of the water at the likely MICS abstraction point, they give an indication of the likely levels of microbiological contamination.

The low levels of microbiological contamination would be easily controlled with the conventional treatment and disinfection methods that are available.

The pH results are also from Dead Mans Point and also give only an indication of the pH of the water. These results suggest that some pH adjustment would be necessary if the water was used for a drinking water supply.

Results from cyanobacteria monitoring have not been identified. Discussion with staff from Otago Regional Council indicated that there have been no positive sample results for cyanobacteria or cyanotoxin from Lakes Wakatipu, Wanaka and Dunstan or from the Clutha River. It was reported that cyanobacteria had been identified in Lake Hayes in the past but not for some years.

Algal blooms, however, do occur in Lake Dunstan, though these have not been identified as cyanobacteria.

Cyanobacteria have been identified in an increasing number of natural waterways in recent years including the Waikato River, Hutt River and Waikanae River. Though clearly not currently a problem, the potential for cyanobacteria blooms in Lake Dunstan exists. This is not prohibitive to using the Lake as a source of drinking-water but needs to be taken into account when considering treatment options.

It is unlikely that any chemical contaminants are present in the lake water at levels that would make the water unsuitable for drinking water supply. The most useful analysis for chemical contaminants is undertaken by the Ministry of Health. Over the last ten years, the

Ministry's Priority 2 Determinand Programme has collected three suites of samples over a period of three years from every registered drinking water supply serving more than 250 people in New Zealand. Any contaminants that exceed 50% of the maximum allowable value set out in the DWSNZ are registered against the supply and are required to be monitored.

By reviewing the contaminants that are listed against drinking water supplies that use water from the Clutha River, it is possible to gain an indication of the contaminants that are likely to be present in the water.

The existing Clyde drinking water supply abstracts drinking water from a shallow bore located close to Dairy Creek. The abstracted water is from Lake Dunstan though it is drawn through gravels on the shore of the lake prior to abstraction. This abstraction method is not expected to affect the levels of chemical contaminants in the water.

Chemical contaminants have not been identified in the Clyde supply by the Ministry of Health Priority 2 Determinand programme. The Roxburgh Village drinking-water supply abstracts water from the Clutha River about 40 kilometres downstream from the Clyde Dam. Priority 2 chemical determinands have not been registered against the Roxburgh Village supply.

Extensive organic chemical and pesticide analyses were undertaken by CODC on raw water from the Clyde intake in March 2007. None of the contaminants exceeded 50% of the maximum allowable values outline in the DWSNZ.

Though it would be necessary to undertake a suite of chemical analyses prior to utilising water from Lake Dunstan for a drinking-water supply, indications are that it is unlikely that the lake water contains chemical contaminants which would preclude its use.

An assessment of the catchment provides a good indication of the suitability of a lake or river system for drinking water supply. The catchment for the Clutha and Kawarau Rivers is extensive. The upper catchment includes alpine forests and grasslands. The catchment close to the lake includes dry stock farming, mainly sheep, orchards and vineyards.

It is expected that the farming activities contribute to the degradation of the water quality, however dry stock farming or horticulture has a significantly lesser effect on water quality than dairy farming.

Discharges of wastewater occur from the townships of Cromwell and Bannockburn. These discharges are expected to have an adverse effect on water quality.

The information available suggests that water from Lake Dunstan would be suitable for use as a drinking water supply. The water would, however, require treatment before it would comply with the DWSNZ. Treatment would need to include filtration to reduce turbidity and disinfection to inactivate micro-organisms. The water does not appear to contain chemical contaminants at a level that would preclude use as a drinking-water supply or require treatment.

4 Water volumes required for Clyde and Alexandra

The required volumes of water for Clyde and Alexandra are based on current and predicted future usage and have been provided by CODC. They are:

- Clyde 6MLD
- Alexandra 20MLD

This level of water use is high for the populations supplied, 1000 people for Clyde and 5000 people for Alexandra. A considerable amount of water is used for garden irrigation due to the dry summer climate. Seasonal population increases also contribute to the high water use.

This report is based on the water use figures above, and does not consider strategies to reduce that level or consider future demand.

The Dairy Creek resource consent allows abstraction of 326,160 m^3 of water from Lake Dunstan daily for a year, except for the period between 31 May and 31 July inclusive. The maximum amount of water that can be abstracted in a year is 98,826,480 m^3.

Taking 26ML for drinking water supply would leave 300ML per day for irrigation purposes. It is expected that this volume would be sufficient for irrigation but would need to be agreed with the MICS and would be dependent on whether MICS utilise storage and how much land is irrigated.

Difficulty arises regarding the months of June and July when the existing MICS consent does not allow abstraction. This matter is considered later in this report.

5 Treatment Options for Compliance with DWSNZ

5.1 Drinking Water Standards

The Health (Drinking Water) Amendment Act 2007 is an amendment to the Health Act 1956 specifically dealing with the regulation of the quality of drinking water. The Act places duties on water suppliers, the most significant of which is the requirement to take *all practicable steps* to meet the drinking water standards. This requirement is phased in over a number of years depending on the size of the drinking water supply. Water supplies are categorised under the Act by the number of people served. A large supply provides water to more than 10,000 people, a medium supply provides water to between 5001 and 10,000 people, a minor supply provides water to between 501 and 5000 people, and a small supply provides water to between 101 an 500 people. Clyde is listed in the Ministry of Health Register of Community Drinking Water Supplies in New Zealand as serving a population of 1000 and Alexandra a population of 5000. This categorises both supplies as minor supplies. When the Act was passed in 2007, minor supplies were required to take all practicable steps to comply with the drinking-water standards by 1 July 2011. In June

2009, the Government extended the dates at which water suppliers would need to comply with the requirements of the Act. This extended the date for minor supplies to 1 July 2014. This date applies to Clyde and Alexandra.

The DWSNZ 2005 (Revised 2008) are the current standard and have been in effect from the 1 January 2009.

The DWSNZ set out maximum allowable values (MAV) for contaminants which may affect drinking water supplies and compliance criteria for bacteria, protozoa, cyanotoxin, chemical and radiological contaminants.

Bacterial compliance criteria cover water leaving a treatment plant and water in a distribution zone. For water leaving a treatment plant, compliance can be demonstrated by sampling and analysis for the microbiological indicator organism *E. coli* or where supplies are chlorinated by monitoring free available chlorine (FAC) levels either continuously or non-continuously.

Bacterial compliance for water in a distribution zone is demonstrated by sampling and analysis for *E. coli*. The number of samples can be reduced by substitution with FAC sampling.

Demonstration of protozoa compliance is specific to the level of protozoa risk of the source water and the technology used for protozoa removal. The DWSNZ set a protozoa log removal level, based on the identified risks of the source water. For supplies serving fewer than 10,000 people, the water supplier is required to undertake a catchment risk assessment to determine the required protozoa log removal level. Surface water supplies and ground water supplies that are subject to surface water influence are required to have a treatment process with a 3-log to 5-log protozoa removal level depending on the catchment risks. Ground water that is not subject to surface water influences can have a 2-log removal level or in some cases where the water is ‘secure’ or highly unlikely to be contaminated with protozoa, treatment for protozoa is not required.

Supplies serving more than 10,000 people are required to undertake a protozoa monitoring programme to determine the level of protozoa contamination of the source water and hence the level of treatment required.

The DWSNZ sets out ‘log credits’ or accepted log removal levels for different treatment technologies. A water supplier is required to match or exceed the log credits of their treatment technologies to the required protozoa removal level of the source water.

The DWSNZ include a section heading for viral compliance. The section states that human pathogenic viruses are likely to be present in catchments which include human activity or wastewater discharges. It suggests that it is possible that some water treatment processes do not control viruses as well as others, but that insufficient information is currently available on this. For this reason, compliance criteria for viruses are not provided. The section suggests that for surface waters, if filtration is not included as a treatment process, then two disinfection processes, one of which is chlorination, should be used to ensure inactivation of viruses.

It has been and remains a general understanding that chlorination at a level which provides a barrier to bacterial contamination also provides a barrier to virus contamination.

Cyanotoxin compliance is less prescribed in the DWSNZ than bacterial, protozoa or chemical compliance. If the source water is at risk of cyanobacterial contamination the water supplier is required to prepare a management plan and have this approved by a Drinking Water Assessor (DWA). The DWSNZ set a MAV for cyanotoxin in water leaving a treatment plant. The water must be monitored if the level exceeds 50% of the MAV.

Chemical compliance is based on chemical contaminants that the Ministry of Health have identified in the source water of a supply. When a new water supply is established, the Ministry of Health undertakes a sampling programme (the Priority 2 Programme) to determine which contaminants or determinands exceed the MAVs or 50% of the MAVs for chemical determinands set out in the DWSNZ. Determinands which exceed 50% of the MAV must be monitored. Water supplies which exceed the MAVs for chemical determinands do not comply with the chemical compliance requirements of the DWSNZ.

Radiological compliance applies to ground water supplies only. All ground water supplies are required to be sampled for radiological contaminants every 10 years to determine if the radiological MAVs set out in the DWSNZ have been exceeded.

5.2 Catchment Risks and Protozoa Removal Level for Lake Dunstan

The catchment for Lake Dunstan is extensive and includes contaminant inputs from a number of sources. Under the DWSNZ, CODC, as the water supplier is required to undertake a catchment risk assessment to determine the level of protozoa removal required. This is the required method for supplies serving fewer than 10,000 people. The DWSNZ provide as an appendix, a *Catchment Risk Categorisation Survey Result Form* to assist the preparation of a catchment assessment.

This method can be applied to a hypothetical supply using water from Lake Dunstan.

Table 5.1a of the DWSNZ reproduced below outlines the log credit requirements for different catchment and groundwater categories. It states that surface waters should be allocated a log removal level of between three and five.

Table 3. From DWSNZ Table 5.1a: Log credit requirements

Catchment or groundwater protozoal risk category	Log credits
Surface waters	
Waters from pastoral catchment with frequent high concentrations of cattle, sheep, horses or humans, or a waste treatment outfall nearby or upstream	5
Waters from pastoral catchment that always has low concentrations of cattle, sheep, horses or humans in immediate vicinity or upstream	4
Water from forest, bush, scrub or tussock catchments with no agricultural activity	3
Groundwaters	
Bore water 0 to 10 m deep and springs are treated as requiring the same log credit as the surface water in the overlying catchment	3–5
Bore water drawn from an unconfined aquifer 10 to 30 m deep, and satisfies groundwater security criteria 2	3
Bore water drawn from deeper than 30 m, and satisfies bore water security criteria 2	2
Secure, interim secure, and provisionally secure bore water	0

From DWSNZ2005 (Revised 2008)

A preliminary consideration of the catchment characteristics indicates that a drinking water supply using Lake Dunstan as source water could be in the category of:

Waters from pastoral catchment with frequent high concentrations of cattle, sheep, horses or humans, or a waste treatment outfall nearby or upstream

This preliminary consideration indicates that 5-log protozoa removal may be necessary.

The required protozoa log removal requirement cannot be confirmed until a detailed catchment risk assessment is undertaken and agreed with the DWA.

If a water supplier believes that the protozoa removal level assigned by the catchment risk method is inappropriate they can appeal the assignation, but must provide cryptosporidium monitoring data as supporting evidence. The cryptosporidium monitoring data would need to replicate the sampling programme of 26 samples taken over a 12 month period, required for supplies serving more than 10,000 people.

Table 5.1b from the DWSNZ reproduced below outlines the protozoa log removal level determined by the mean number of oocysts/10L, where the cryptosporidium monitoring option is used.

Table 4. From DWSNZ Table 5.1b: Log credit requirements

***Cryptosporidium*, mean oocysts per 10 litres**	**Log credits**
≥ 10	5
0.75–9.99	4
< 0.75	3

From DWSNZ2005 (Revised 2008)

It is possible that cryptosporidium monitoring would identify that a lower protozoa removal level than 5-log was required. Consideration needs to be given to using cryptosporidium monitoring to determine the required level of protozoa log removal

5.3 Water Treatment Options for Water Taken from Lake Dunstan

Water from Lake Dunstan utilised for a drinking-water supply which was to comply with the DWSNZ would require the following treatment:

- A barrier to bacterial contamination
- A barrier to protozoa contamination (3-log – 5-log)
- A barrier to cyanotoxin contamination. This would only be utilised when there was evidence of cyanobacterial contamination of the source water.

A bacterial barrier compliant with the DWSNZ can be provided in a number of ways. The DWSNZ allow water supplies to be disinfected with chlorine, chlorine dioxide, ozone and UV.

A protozoa barrier can be provided by a number of treatment processes or combinations of treatment processes.

Water from Lake Dunstan is subject to varying turbidity and a filtration process will be required to remove particulate material and reduce turbidity to a level at which disinfection could be achieved.

Membrane filtration can achieve a protozoa log credit of up to 6-log. The manufacturer of a membrane technology is required by the DWSNZ to provide certification to demonstrate the level of protozoa log removal that their equipment can achieve. To date in New Zealand, membrane plants have only been certified to provide 4-log protozoa removal.

Membrane filtration includes a number of different membrane processes including microfiltration, ultrafiltration, nanofiltration and reverse osmosis.

Rapid sand filtration processes can achieve a protozoa log credit of 2.5-log if a coagulant is dosed prior to the filter. Sand filtration that is preceded by coagulation and clarification can achieve a log credit of 3-log. A further log credit of 1-log (for a total of 4-log) can be achieved by providing *enhanced individual performance*, or meeting a higher turbidity standard.

The filtration processes of diatomaceous earth and slow sand filtration can achieve a log credit of 2.5-log. Cartridge filtration can achieve a log credit of 2-log and bag filtration can achieve a log credit of 1-log.

A further log credit of 0.5 or 1-log can be achieved when bank filtration is used prior to other treatment processes depending on the set back distance between the well and surface water. The DWSNZ outline a number of criteria that must be met if bank filtration is to be used to contribute to the treatment process log credits.

When a disinfection process is used in association with a filtration process, the log credits of each process can be added together to provide a cumulative protozoa log removal level.

Chlorine dioxide and ozone disinfection can achieve a log credit of up to 3-log depending on the contact times achieved. UV disinfection can achieve a log credit of up to 3-log depending on the dose (fluence) delivered.

Table 5 outlines the treatment processes that are compliant with the DWSNZ and the protozoa log credits allocated to each process.

Table 5. Protozoa treatment process log credits

Treatment process	Log credits	Comments
Filtration		
Bank filtration	Up to 1	0.5 or 1 depending on setback
Coagulation/sedimentation/ sand filtration	3	
Coagulation/direct filtration	2.5	
Second stage filtration	0.5	Can be added to other processes
Enhanced combined filter performance	0.5	Applies to coag/sed/ filtration or coag/direct filtration
Enhanced individual filter performance	1	Applies to coag/sed/ filtration or coag/direct filtration
Diatomaceous earth filtration	2.5	
Slow sand filtration	2.5	
Membrane filtration	4*	Dependent on certification by manufacturer
Cartridge filtration	2	
Bag filtration	1	
Disinfection		

Chlorine dioxide	Up to 3	Dependent on contact time
Ozone	Up to 3	Dependent on contact time
Ultraviolet light	Up to 3	Dependent on dose (fluence)

* Membrane technology providing up to 4-log protozoa removal has been certified in New Zealand however manufacturers claim that up to 6-log removal can be achieved.

The table below illustrates how a combination of different processes can be used to achieve an increased protozoa removal log credit.

Table 6. Protozoa treatment process log credit combinations

Treatment process	Single process	Bank filtration (best case 1log)	Enhanced combined filter performance	Enhanced individual filter performance	Second stage filtration or cartridge or bag	Chlorine dioxide (best case 3-log)	Ozone (best case 3-log)	UV (best case 3-log)
Coagulation/sedimentation/filtration	3	4	3.5	4	3.5	6	6	6
Coagulation/direct filtration	2.5	3.5	3	3.5	3	5.5	5.5	5.5
Diatomaceous earth filtration	2.5	3.5	N/A	N/A	N/A	5.5	5.5	5.5
Slow sand filtration	2.5	3.5	N/A	N/A	N/A	5.5	5.5	5.5
Membrane filtration	4*	5*	N/A	N/A	N/A	7*	7*	7*
Cartridge filtration	2	3	N/A	N/A	N/A	5	5	5
Bag filtration	1	2	N/A	N/A	N/A	4	4	4

* Membrane technology providing up to 4-log protozoa removal has been certified in New Zealand however manufacturers claim that up to 6-log removal can be achieved.

Each of the protozoa disinfection processes outlined above is also considered to be effective against bacteria. A disinfection process installed as a barrier to protozoa can also achieve DWSNZ treatment plant compliance for bacterial disinfection.

Because Lake Dunstan has a risk of cyanobacterial blooms and hence a risk of cyanotoxin contamination, it would be necessary to develop a protocol for the management of cyanobacteria and cyanotoxin. When there is a risk of cyanotoxins being present in water leaving the treatment plant, it would be necessary to provide treatment to remove the cyanotoxins and monitor the water supply for cyanotoxins.

6 Preferred Water Treatment Options for Water from Lake Dunstan

Surface waters from erodible catchments can be expected to contain suspended solids and organic material. The water from Lake Dunstan is no exception and is known to experience periods of increased turbidity. Any treatment process will require filtration to remove particulate material.

For the purposes of this study the treatment proposals are built around a 5-log protozoa removal requirement. This may be a conservative assessment and a lesser log removal level may be justified.

Slow sand filtration, bag filtration, cartridge filtration and diatomaceous earth are processes that are not considered suitable for treatment of high volumes of water with moderate to high levels of suspended solids or particulate matter. These processes would not be suitable for treating the volumes of water required for the communities of Alexandra and Clyde.

The remaining filtration options include sand filtration with coagulation and sedimentation, direct sand filtration, or membrane filtration.

The direct sand filtration process doses a coagulant prior to the sand filters, without a clarification/sedimentation stage. In New Zealand conditions, this process has been found to be inadequate where there are rapid turbidity changes or high turbidity loads. Direct sand filtration would be unlikely to provide sufficiently efficient filtration to maintain the final water turbidity requirements of the DWSNZ.

The filtration processes that are considered suitable for removing particulate material from water taken from Lake Dunstan, to a standard that would consistently meet the requirements of the DWSNZ are either:

- Coagulation/sedimentation/sand filtration
- Membrane filtration (microfiltration)

The coagulation/sedimentation/sand filtration process can be achieved in a number of different formats. Conventional (or classic) coagulation/sedimentation/sand filtration usually consists of a coagulant mixing process, flocculation and sedimentation in a sedimentation tank or clarifier, with clarified water flowing to sand filters.

Another process used at a couple of locations in New Zealand uses a coagulant and dissolved air floatation (DAF), a process where air is used to carry the coagulated floc particles to the water surface where they are removed. Clear water is removed from the bottom of the DAF tank prior to filtration. In one example of this process in New Zealand, the sand filter and DAF tank are combined in what is described as a 'DAF over sand' process.

Coagulation/sedimentation/sand filtration has the ability to achieve a protozoa log credit of 3-log. This can be improved to 3.5-log if the filtration process meets the enhanced combined filter performance criteria, and to 4-log if the filtration process meets the enhanced individual filter performance criteria outlined in the DWSNZ. If 5-log credits for protozoa removal are required and coagulation/sedimentation/sand filtration was used, a further disinfection process would also be required to achieve the 5 log .credit total.

Membrane filtration is a technology which is being installed in new and upgraded water treatment plants in New Zealand. There are a number of types of membrane filtration including microfiltration, ultrafiltration, nanofiltration and reverse osmosis. To date, most installations in New Zealand have been microfiltration. Microfiltration is a pressure or vacuum-driven separation process in which particulate material larger than the pore size of the membrane is rejected through a size exclusion mechanism. Membrane technology is modular with higher numbers of modules being used where higher treated water volumes are required.

The protozoa log credits that can be achieved by a membrane process vary depending on the performance that has been demonstrated and certified for a particular model by the manufacturer. Membrane technology manufacturers are required to provide certification of the protozoa log removal capability of their equipment. The certification is based on challenge and other testing methods.

Typically membrane filtration can achieve 4-log protozoa removal but in some cases up to 6-log.

Membrane filtration can be operated with the addition of a coagulant prior to the membranes to improve the performance where waters are highly turbid or contain very fine particles.

If 5-log protozoa removal is required and membrane technology was to be used, the technology would need to either be certified for protozoa removal of 5-log, or if certified for a protozoa removal of 4-log, a disinfection process (e.g. UV) which provided further protozoa log credits would be required to ensure the log credit of the combined processes equaled 5-log.

It will also be necessary to provide a barrier to non-protozoan micro-organisms, specifically bacteria and viruses. This can be achieved by a number of differing technologies, not all of which would be suitable for a treatment plant at Clyde or Alexandra.

Chlorine dioxide is not commonly used in New Zealand and hence there is little local experience with this disinfectant. Previous experience at a New Plymouth water treatment plant has resulted in chlorite and chlorate formation, as well as combustion of sodium chlorite and organic materials. Overseas experience has suggested that chlorine dioxide can produce taste and odour complaints due to reactions with organics. Chlorine dioxide is an unstable compound and is produced on site from highly hazardous and explosive materials, requiring storage in a dark room and specific operator training. The chemicals are required to be stored at a minimum temperature of 15°C. When a chlorine dioxide system is installed, chlorites automatically become a Priority 2 Determinand and require additional monitoring.

Chlorine dioxide is not considered a suitable disinfectant for the circumstances at Clyde and Alexandra.

Ozone gas is a powerful oxidant and ozone disinfection is therefore very effective against protozoa bacteria and viruses. Ozone cannot be stored and must be produced at the treatment plant requiring a large amount of electricity to create a high voltage discharge and very dry air (through air drying). Alternatively, oxygen can be used, though this has additional safety issues. The ozone is difficult to dissolve in the water stream and large contact tanks are required. The undissolved “off-gas” requires collection and destruction, usually in a catalytic destructor as ozone gas is very toxic. Ozone is corrosive to most materials and only very high quality stainless steel is suitable for use in ozone plants. There are high capital and operational costs when ozone is used as a disinfectant and it does not provide residual disinfection. It is not considered that ozone disinfection is a suitable disinfectant for the circumstances at Clyde and Alexandra.

The most suitable methods for providing adequate disinfection for non-protozoan microorganisms are by dosing with chlorine or by UV disinfection. Each technology has advantages and disadvantages.

UV disinfection while providing a barrier to non-protozoan micro-organisms also provides a barrier to protozoa and can achieve up to 3-log credits. The disadvantage of UV disinfection is that it does not provide a residual disinfectant.

Chlorination is typically used to provide a non-protozoan microbiological barrier. The advantage of chlorination is that it provides a residual disinfectant within the distribution system. The disadvantages of chlorine are that it does not provide a barrier to protozoa and because it is a hazardous substance, requires specific training and qualifications for those who handle it.

Chlorination of water supplies also creates a risk of the formation of disinfection by-products. Disinfection by-products form when chlorine combines with organic material present in water. Disinfection by-products are carcinogens. The formation of disinfection by-products can be prevented by providing efficient filtration systems which remove a high percentage of organic and particulate matter prior to chlorination. Water from Lake Dunstan if chlorinated would be at high risk of disinfection by-product formation if filtration processes prior to chlorination do not achieve low turbidities and high removal of organics and particulates.

Regardless of the protozoa barrier preferred, it is recommended that the supply is chlorinated. Chlorine will provide a residual disinfectant which provides some protection to recontamination of the water at reservoirs or within the distribution system. The monitoring of chlorinated supplies for DWSNZ bacterial compliance is considerably less than for non-chlorinated supplies. For chlorinated supplies, compliance monitoring of water leaving the treatment plant can be achieved by monitoring FAC. Non-chlorinated supplies are required to monitor *E. coli*. Chlorinated supplies can substitute 75% of *E. coli* monitoring in the distribution zone with FAC monitoring.

Chlorinated supplies are likely to achieve higher scores in the Ministry of Health, Public Health Grading of drinking-water supplies.

There is a risk of contamination of Lake Dunstan with cyanobacteria and cyanotoxins. Cyanobacteria blooms are intermittent and seasonal. Treatment for cyanotoxin requires dosing of powdered activated carbon (PAC) prior to filtration. A number of water treatment plants in New Zealand are currently operating this system. It is considered that the facility to dose PAC will be required with any filtration process treating water from Lake Dunstan.

Three treatment options are recommended for treating water from Lake Dunstan to a protozoa removal level of 5-log.

(i) Conventional coagulation/sedimentation/sand filtration (4-log) followed by UV disinfection (3-log) and chlorination with standby PAC dosing

(ii) Membrane filtration (microfiltration) with coagulant dosing (4-log), followed by UV disinfection (3-log) and chlorination with standby PAC dosing.

(iii) Membrane filtration (microfiltration) with coagulant dosing (5-log), followed by chlorination with standby PAC dosing.

For all three options, it will be necessary to include pH correction because when a coagulant is added it decreases the pH. Soda ash dosing could be used to correct the pH so that it was within the DWSNZ guideline value of 6.5 to 8. With an alkalinity of 30 g/m^3s, the water will be corrosive to metallic plumbing and water mains. Consideration would need to be given to also providing some corrosion protection.

Options (i) and (ii) would achieve a total protozoa removal level of 7-log. Option iii would achieve a total protozoa removal level of 5-log.

If a lesser protozoa log removal level of 4-log or 3-log is required, options (i) and (ii) would be recommended but without UV disinfection.

7 Utilising the Manuherikia Irrigation Cooperative Society Consented Water Take

There are a number of options for the provision of drinking water to Clyde and/or Alexandra utilising water from Lake Dunstan, however with each of the options there are also issues.

The two water supply options under consideration in this report are:

- **Option 1**

Building a 26MLD water treatment plant to provide water to Clyde and to Alexandra.

- **Option 2**

Building a new 6MLD treatment plant at Clyde and building a 20MLD treatment plant at Alexandra.

Both water supply options would utilise water abstracted from Lake Dunstan.

7.1 Access to the Source Water

If the MICS irrigation scheme was to go ahead, irrigation water would be abstracted from an intake at Lake Dunstan close to the Clyde Dam. Though details at this stage are not finalised, it is expected that water would be pumped from the intake to a pipeline which would follow State Highway 8 and would carry the water to storage sites and the areas which will be irrigated. Decisions have not yet been made on the best storage locations but a favoured option is to provide irrigation water storage in Muttontown at the northern end of the airstrip.

7.1.1 Access to water for option 1

For option 1, access to water from Lake Dunstan for a single treatment plant at Clyde would depend on the location of the treatment plant.

If a treatment plant was located at Clyde, it would be possible to take 26MLD of water from the irrigation pipeline at its closest point to the treatment plant. This would require a connecting pipeline and pumping capacity if there is insufficient gradient to provide a gravity feed.

Alternatively, a dedicated intake and pipeline could be constructed from the lake to the treatment plant, or the existing bore which currently supplies Clyde, or the backup Clyde Dam intake and existing pipeline could be utilised and modified if necessary.

If MICS constructs a storage facility at the northern end of the airstrip in Muttontown, CODC could have the option of constructing a treatment plant near to that site and providing water to Clyde and Alexandra via pipelines. It would be necessary to provide pumping for both pipelines.

7.1.2 Access to water for option 2

Option 2 would require access to Lake Dunstan water for treatment plants at both Clyde and Alexandra.

For Clyde there are two options:

- Utilise the existing lake side bores and consents and connect them to the new treatment plant.
- Connect to the irrigation pipeline at its closest point to the treatment plant.

For Alexandra the most obvious option would be to locate the treatment plant near to the existing reservoir and to take water from the irrigation pipeline at its closest point.

7.2 Treated water delivery

The difficulty of delivery of treated water for option 1 would depend on the location of the treatment plant. If the treatment plant was located near to Clyde, it would be relatively straightforward to supply water to Clyde. However, delivery of treated water to Alexandra would be more difficult under option 1. If a treatment plant was constructed at Clyde, a 9 kilometre treated water pipeline to Alexandra would be required. This option was considered in a previous Opus report, *Alexandra and Environs Water Option Study* completed in October 2007. That report identified the need for a 10 kilometre pipeline and large diameter (around DN500) water main at a cost of approximately $5 million. If a treatment plant was constructed at Muttontown, treated water pipelines would be required to supply water from the treatment plant to Alexandra and from the treatment plant to Clyde.

Delivery of treated water for option 2 would be relatively straightforward as the treatment plants would be located close to the distribution systems of both Clyde and Alexandra. The configuration of the distribution systems would not need to change if water can be supplied to the existing reservoirs. If this is not possible, it would be necessary to develop a model of the distribution system to determine if any changes would be required to ensure adequate pressures and volumes were available throughout the whole system.

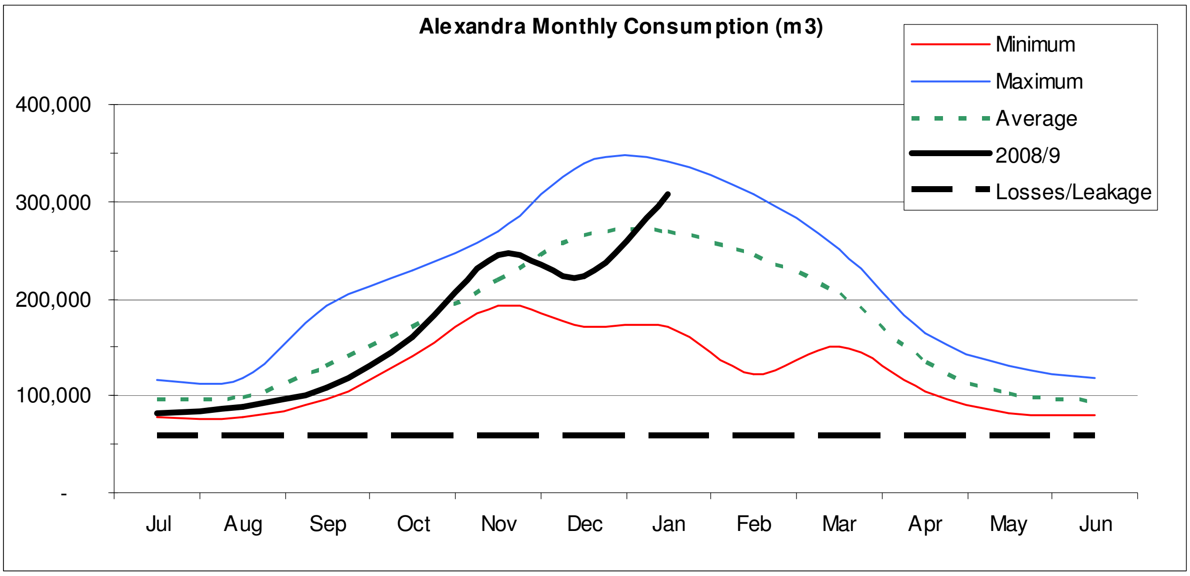
7.3 Managing the Unavailability of Consented Water in June and July

Regardless of the options that are preferred for accessing, treating and delivering water abstracted from Lake Dunstan for a drinking water supply under the MICS consent, there remains the problem that the consent does not allow the abstraction of water from 31 May to 31 July inclusive. This is a total period of 62 days.

Data provided by CODC identifies that the June and July water consumption for Alexandra has not exceeded 118,225m^3/month for the seven years from 2002 until 2008 inclusive and the June and July water consumption for Clyde has not exceeded 25,220m^3/month. This gives a total maximum usage of 143,445m^3/month or 143 ML/month. To provide some security, a figure of 150 ML/month has been considered as the required drinking water demand for Clyde and Alexandra during the months of June and July. This equates to a figure of 5 MLD.

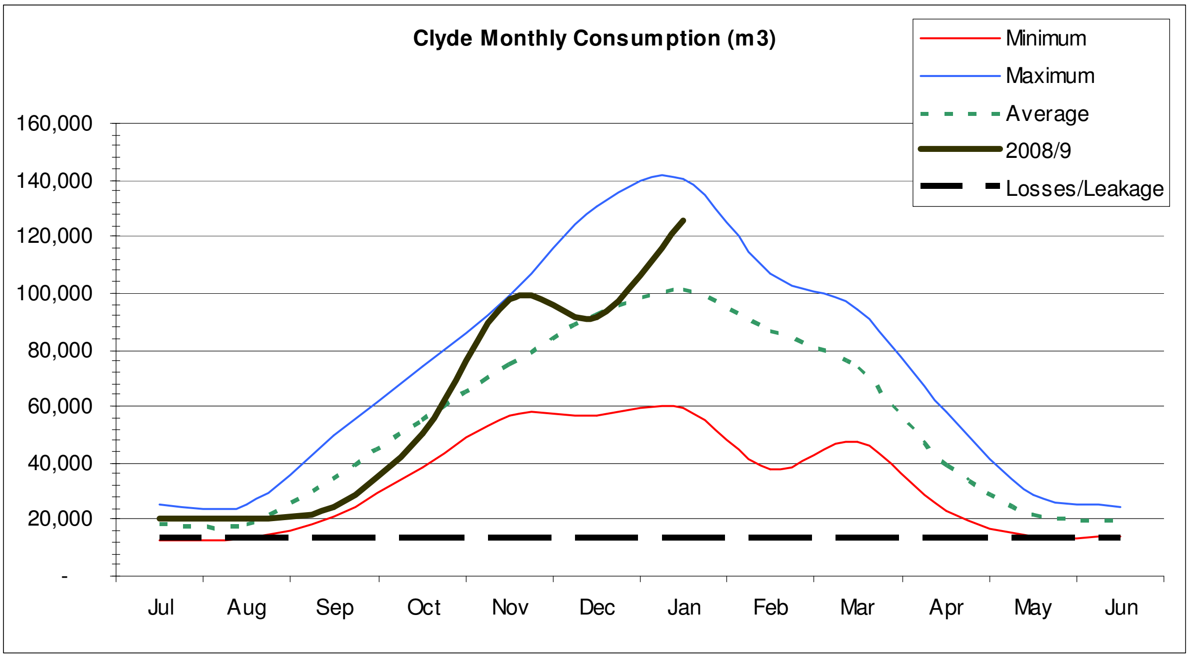
Three options are considered for providing 5 MLD of water during the months of June and July when the MICS consent does not permit the abstraction of water from Lake Dunstan.

Figure 1. Alexandra water consumption



Courtesy of Central Otago District Council

Figure 2. Clyde water consumption



Courtesy of Central Otago District Council

7.3.1 Option A. Changes to the Manuherikia Irrigation Cooperative Society Resource Consent

The MICS has been issued a resource consent to take water for the purpose of irrigation and frost fighting from an abstraction point where Dairy Creek discharges into Lake Dunstan.

Investigations undertaken by Opus have identified that this location is not suitable for abstraction of water. It is likely that if the irrigation scheme is to be progressed that changes to the consent will be required. This will necessitate returning to the consent authority, the Otago Regional Council, and seeking changes to the consent conditions. If it is intended to use water taken under the MICS consent for the supply of drinking water, it may be necessary to change the consent to allow water to be taken for the purposes of supplying drinking water as well as for irrigation and frost fighting. It is likely that these matters would be accepted by the consenting authority as variations to the existing consent.

Changing the conditions of the original consent would allow an opportunity to change the consented timeframes for abstraction. The variation could be to take the existing quantity of water for irrigation, frost fighting and water supply and 5 MLD of water during June and July for the purpose of supplying drinking water only.

Section 14 of the Resource Management Act states that priority should be given to the use of water for drinking-water supply. For this reason, it is likely that a variation to the MICS consent to allow abstraction of water during June and July for the purpose of supplying drinking water would be successful.

7.3.2 Option B. Utilisation of Existing Consented Water Takes

CODC currently holds two resource consents to abstract water for town supply for Clyde. Consent 2001.948 allows abstraction of up to 10 MLD from bores on the true left bank of Lake Dunstan about 500 metres upstream of the dam. Consent 2007.244 allows the abstraction of up to 6 MLD of surface water from the north-eastern side of the Clyde dam for the purpose of auxiliary supply of drinking water for Clyde. The consent to take surface water from the lake can only be used when the consent to abstract groundwater is not being used. Water can be supplied from the bore or the surface water intake, but not both at the same time.

CODC could use the existing consent, water permit 2001.948 granted in 2002, which allows abstraction of up to 10MLD from the bore for town supply for Clyde, to supply water to both Clyde and Alexandra during the months of June and July. The consented amount of 10 MLD exceeds the maximum demand during June and July by a factor of two.

Water would be taken from the MICS pipeline at Clyde from August to May each year but during the months of June and July, water would be abstracted from the existing bore.

7.3.3 Option C. Utilisation of Stored Irrigation Water

It is likely that the MICS will require storage for water that is abstracted from Lake Dunstan for irrigation. A number of options have been proposed for this ranging from a very large single reservoir to a number of smaller reservoirs. The final location and quantity of storage has not yet been determined, however one proposal is to store water for irrigation at the northern end of the airstrip at Muttontown. Storage of irrigation water could provide a supply of drinking water during the months of June and July when abstraction is not permitted by the MICS consent.

Potentially up to about 300 ML of water would be required over the June/July period and the storage would need to accommodate this amount.

If however the MICS consent is varied as outlined in option A above, to allow abstraction of drinking water all year, or existing CODC consents are used during June and July to provide water, as outlined in option B above, it would be possible to provide water all year to the MICS storage facility via the MICS pipeline and the size of the storage facility would become irrelevant.

7.4 Rural Agricultural Drinking Water Supplies

If an agreement to utilise water from Lake Dunstan abstracted under the MICS consent to supply drinking-water for Clyde and Alexandra is achieved, the requirements of the Health (Drinking Water) Amendment Act would need to be considered. It is usual for water supplies to abstract water from a bore, stream or lake specifically for the purpose of the supplying drinking water. In some circumstances, water from an irrigation scheme is used to supply a small community. It would be unusual to supply two towns with a combined population of 6000 from an irrigation supply. It is important to understand the implications of this situation for the regulation of the quality of the drinking water.

Under the Health (Drinking Water) Amendment Act 2007, any water supplier who provides water for household use including rural supplies is required to take all practicable steps to comply with the DWSNZ.

The Act includes a category of water supply called a Rural Agricultural Drinking Water Supply. The intention of this category is to allow rural supplies to continue to provide water that is not potable, or not known to be safe to drink, for stock watering or irrigation use. However, households connected to these supplies are required to treat the water at each house to an acceptable standard. The Ministry intends to include a section into the DWSNZ for these supplies.

The Act sets a date of 1 July 2013 when rural agricultural drinking water supplies must comply with the Act and meet the new section of the standards, however this date has recently been extended to 1 July 2016.

A rural agricultural drinking water supply is defined as a water supply from which 75% or more of the total water supplied is used in commercial agriculture and the supply does not provide water to a town or a village of 50 people or more.

When a rural supply does provide water to a town or village, the Act allows water suppliers to consider the town as a separate supply that uses the rural supply as a water source. Only the water supplied to the town needs to meet the main part of the DWSNZ. This could allow a water supplier to install a treatment plant at the town and treat only the water that the town needs.

So for rural supplies the Act provides two options:

1. Application of the main parts of the standard to the whole water supply and treatment for all of the supply, including stock and irrigation water, to be potable safe drinking water which complies with the DWSNZ.

2. Designate the supply as a Rural Agricultural Drinking Water Supply and

- provide non-potable water for stock/irrigation use,
- install small treatment devices at each rural house on the supply,
- provide treatment to meet the DWSNZ at any town serving more than 50 people that also uses the supply.

If CODC selected the option of abstracting water for Clyde and/or Alexandra from a water pipeline which supplied water for agricultural purposes it would be making use of the Rural Agricultural Drinking Water Supply provisions of the Health (Drinking Water) Amendment Act. It would be necessary to ensure that the appropriate registration requirements were in place for the supply. This would not be difficult. The MICS scheme would need to be listed on the Ministry of Health, *Register of Community Drinking Water Supplies* as a Rural Agricultural Drinking Water Supply. The registrations for Clyde and Alexandra would need to be changed to reflect that the water sources are the MICS scheme.

It would then be necessary under the provisions of the DWSNZ to demonstrate that the houses receiving non-potable water directly from the MICS irrigation scheme were treating the water at each household so that it was safe to drink. To date the Ministry of Health has not finalised the section in the DWSNZ that would deal with this situation, however the Ministry has indicated that the intention of this section would be to allow houses to install point of entry devices that met a certain standard. It is not clear yet whether the cost of installation and maintenance of these devices would be the responsibility of the water supplier or the householder, but it is expected that it would be the householder. The technology usually used in these situations is a cartridge filter and UV disinfection system. The installed cost is usually between $1000 and $1500 per household.

8 Capital and Operational Cost Estimates

Operating and capital costs have been calculated for three water treatment options and for three different treatment plant sizes. The treatment requirements are based around 5-log protozoa removal which is a conservative assessment. It may be that the requirement for a lesser protozoa removal level can be demonstrated.

The treatment options are conventional coagulation/sedimentation/sand filtration or membrane (micro) filtration. The conventional treatment option would provide a protozoa log credit of 3-log, though this would be expected to be increased to 4-log as enhanced individual filter performance would be achieved. UV disinfection would be required to achieve the additional log credits to make up to 5-log.

Two membrane treatment options are provided to meet a protozoa log credit of 5-log: 4-log membrane filtration with UV disinfection to achieve the additional log credits to make up to 5-log, and 5-log membrane filtration without UV disinfection.

All options include chlorination and standby PAC dosing.

The treatment plant sizes are based on:

- Clyde only treatment plant 6MLD
- Alexandra only treatment plant 20MLD
- Clyde/Alexandra treatment plant 26MLD

The costs are for water treatment only and do not include the costs of pumping, storage reservoirs or other associated infrastructure.

Actual costs could be 5% lower or up to 30% higher.

Net Present Value costs, i = 8%, N = 25 years.

Table 7. Conventional treatment costs

Conventional treatment (4-log) With UV, Cl_2, and PAC (Total 7-log)	6 MLD ($)	20 MLD ($)	26 MLD ($)
Capital Costs	4,950,000	9,000,000	11,500,000
Annual Operating Costs	240,000	548,000	676,000
NPV of Operating Costs	2,562,000	5,850,000	7,216,000

Table 8. Membrane filtration costs

Membrane filtration (4-log) With UV, Cl_2, and PAC (total 7 log) **Or Membrane filtration (5-log) with Cl_2 and PAC** (total 5-log)	6 MLD	20 MLD	26 MLD
	($)	($)	($)
Capital Costs	4,950,000	9,000,000	11,500,000
Annual Operating Costs	287,000	636,000	782,000
NPV of Operating Costs	3,064,000	6,789,000	8,348,000

The capital costs of conventional treatment and the newer membrane technology is now about the same. Until recently, the cost of membrane technology had been about 20% higher.

The capital cost of the two membrane filtration options is the same. The cost increase in achieving 5-log protozoa removal is off-set by the saving from not installing UV disinfection. The operational costs are also very similar.

The operational costs of membrane technology are about 16% higher than for conventional treatment processes. This has been determined from work that Opus has done for Dunedin City Council on the Mt Grand and Southern water treatment plants.

The Capital costs are 9% higher and the operational costs 16% higher than the conventional treatment plant costs calculated in 2007 for the *Opus report Alexandra and Environs, Water Options Study*.

If the protozoa removal requirement is reduced to 3 or 4 log, conventional treatment or membrane filtration could be utilised without UV treatment. This would reduce the capital and operational costs by about 10%.

Construction costs have been calculated for pipelines that would be required if a single treatment plant was constructed to provide water to both Alexandra and Clyde. This is option 1 outlined above.

The scenarios that have been considered are a treatment plant at Clyde and a treated water pipeline to Alexandra, and a treatment plant at Muttontown with a treated water pipeline to Clyde and a treated water pipeline to Alexandra.

Table 9. Pipeline from Clyde TP to Alexandra

	Unit	Qty	Rate	Cost
710 OD PE100 PN8	m	2250	820	$1,845,000
560 OD PE100 PN8	m	7300	575	$4,197,500

355 OD PE 100 PN8	m	200	240	$48,000
Air valves	ea	10	5000	$50,000
Road crossings	ea	7	10,000	$70,000
P&G	LS	1	20%	$1242,100
			Total	**$7,452,600**

Table 10. Pipeline from Muttontown TP to Alexandra

	Unit	Qty	Rate	Cost
710 OD PE100PN8	m	500	820	$410,000
560 OD PE100 PN8	m	5600	575	$3,220,000
Air valves	ea	7	5000	$35,000
Road crossings	ea	3	10,000	$30,000
P&G	LS	1	20%	$657,000
			Total	**$4,352,000**

Table 11. Pipeline from Muttontown TP to Clyde

	Unit	Qty	Rate	Cost
355 OD PE 100 PN8	m	2000	240	$480,000
Air valves	ea	3	5000	$15,000
Road crossings	ea	1	10,000	$10,000
P&G	LS	1	20%	$101,000
			Total	**$606,000**

Confidence range +/- 30%

9 Water Supply Scenarios

Three water supply scenarios are proposed for consideration.

9.1 Scenario A

This scenario takes MICS irrigation water from the irrigation pipeline at Clyde. The water is treated at a 26 MLD plant to meet the DWSNZ. Treated water is supplied to Clyde and pumped to Alexandra via a 9 kilometre pipeline.

During the months of June and July when the current MICS consent does not allow abstraction, water can be pumped from the Muttontown irrigation storage reservoir back to the Clyde treatment plant via the irrigation pipeline. Alternatively during June and July, water can be taken from Lake Dunstan under existing CODC water take consents or a varied MICS water take consent.

Table 12. Scenario A costs

Infrastructure	Cost
26MLD Treatment plant at Clyde	$11,500,00M
Pump station at Clyde	$70,000
Pump station at MICS reservoir	$70,000
Treated water pipeline from Clyde to Alexandra	$7,452,000
Approximate Total cost	**$19,092,000**

9.2 Scenario B

This scenario utilises water from the MICS irrigation storage reservoir throughout the year. It would require the construction of a 26MLD treatment plant adjacent to the MICS storage reservoir, a pump station and treated water pipelines from the treatment plant to both Clyde and Alexandra.

During the months of June and July when the current MICS consent does not allow abstraction, water from the Muttontown irrigation storage reservoir would be utilised.

Alternatively the MICS consent could be modified or existing CODC consents could be used to provide a sufficient quantity of water to the storage reservoir all year round.

Table 13. Scenario B costs

Infrastructure	Cost
26MLD Treatment plant adjacent to MICS storage at Muttontown	$11,500,000
Pump station at treatment plant	$70,000
Pipeline from treatment plant to Alexandra	$4,353,000
Pipeline from treatment plant to Clyde	$606,000
Approximate Total cost	**$16,529,000**

9.3 Scenario C

This scenario utilises water from the MICS irrigation scheme at a 6MLD treatment plant located at Clyde and a 20MLD treatment plant located at Alexandra.

During the months of June and July when the current MICS consent does not allow abstraction, water can be pumped from the Muttontown irrigation storage reservoir to both the Clyde and Alexandra treatment plants via the irrigation pipeline.

Alternatively during June and July, water can be taken from Lake Dunstan under a varied MICS water take consent or existing CODC consents.

Table 14. Scenario C costs

Infrastructure	Cost
6MLD Treatment plant at Clyde	$4,950,000
20MLD Treatment plant at Alexandra	$9,000,000
Pump station at MICS reservoir	$70,000
Pump station at Alexandra treatment plant	$70,000
Approximate Total cost	**$14,090,000**

Figure 3. Scenario A

Figure 4. Scenario B

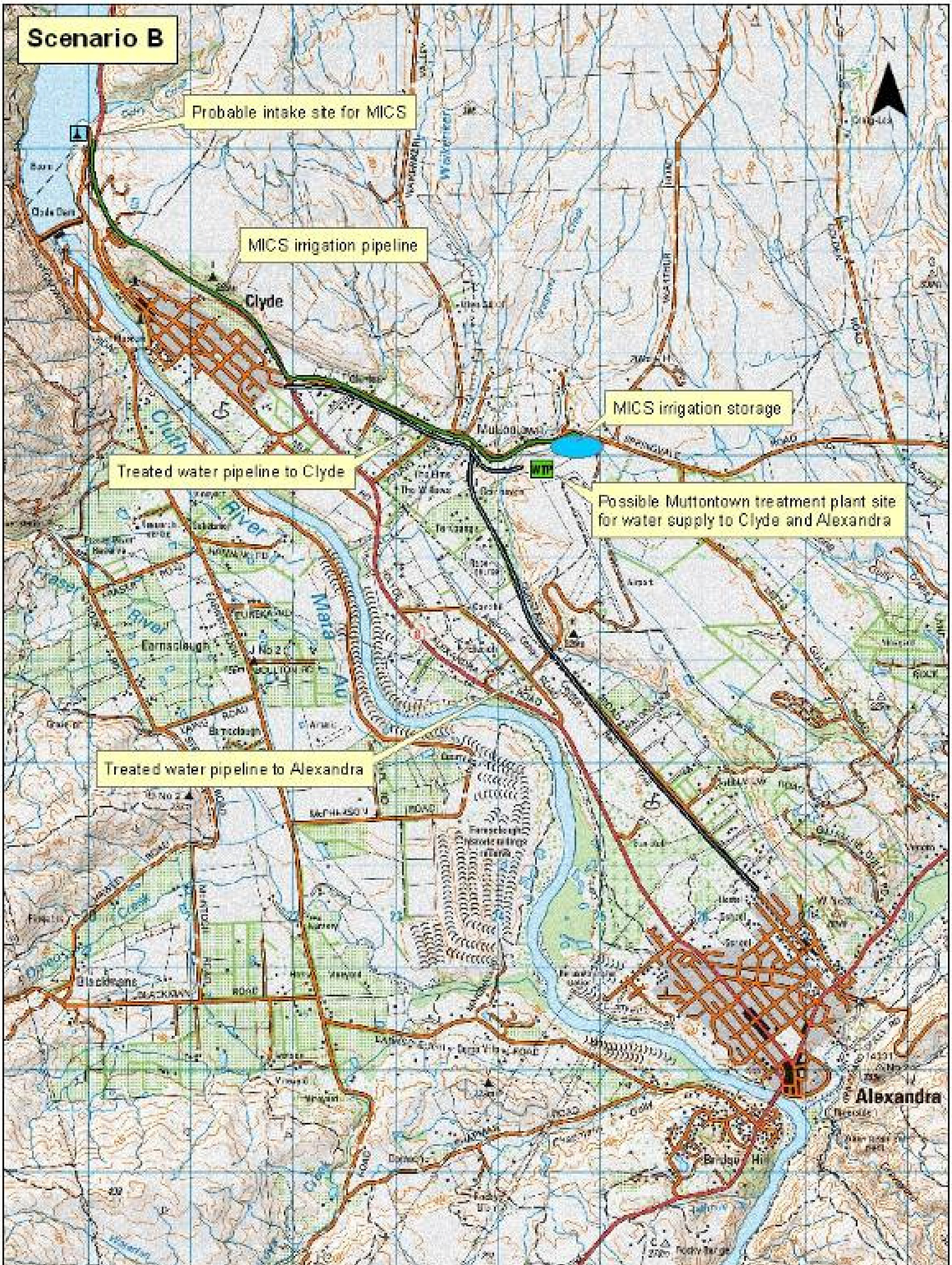


Figure 5. Scenario C

10 Option Advantages and Disadvantages

10.1 Water treatment options

There are advantages and disadvantages associated with any water treatment technology. The table below outlines some of the advantages and disadvantages of conventional and membrane technology.

Table 15. Treatment process advantages and disadvantages

Type of Plant	Advantages	Disadvantages
Conventional Treatment	• Lower energy input required. • Process will remove some soluble contaminants. • Backwashing of filters usually at 24 to 48 hour intervals. • Lower volumes of waste of which to dispose. • Process can be run manually if required. • Operating costs tend to be lower than membrane filtration operating costs.	• Complicated process with a number of interdependent processes. • Requires skilled operators to ensure process removes all the contaminants from the raw water. • Requires a relatively high level of operational input. • Not a physical barrier to protozoa. • Can only achieve up to 4-log protozoa removal • Process has 3 distinct stages, all of which must operate optimally. • Higher level of maintenance required • Process is dependent on the use of coagulation chemicals
Membrane Filtration	• Involves a single stage process. • Relatively simple and easy to operate process. • Process is a physical barrier to protozoa. • Usually operated without a coagulant. • Can achieve up to 5-log protozoa removal. • Modular process means it is easy to increase the treated water volume by adding more units. • Lower pressures in system allow use of peristaltic pumps. • Cost is reducing	• Higher energy, (pumping) costs • Requires chemicals for membrane cleaning. • Cleaning chemicals need to be neutralised before disposal. • Coagulant required for organics and silt / clay sized turbidity removal. • Cannot be run manually (apart from start-stop). • Silica levels in the raw water can reduce the life of the membranes • Recycling of waste streams

10.2 Supply configuration options

Supply configuration is determined by the most suitable method to abstract water, and the most suitable location for a treatment plant or plants. Three scenarios have been proposed each with advantages and disadvantages.

Table 16. Scenario A advantages and disadvantages

Advantages	**Disadvantages**
• Requires the construction of only one treatment plant • Treatment plant operating costs are less than scenario C (2 treatment plants) • Could utilise the existing Clyde reservoir site for the treatment plant • Allows DWSNZ compliant water to be provided to properties between Clyde and Alexandra. • Provides good options for expansion of the treated water supply to new areas of subdivision. • Could include bulk storage for both Clyde and Alexandra at the Clyde treatment plant site.	• Requires the construction of a dedicated treated water pipeline from Clyde to Alexandra • Capital cost is highest of three scenarios at $19,092,000

Table 17. Scenario B advantages and disadvantages

Advantages	Disadvantages
• Requires the construction of only one treatment plant. • Treatment plant operating costs are less than scenario C (2 treatment plants) • Allows DWSNZ compliant water to be provided to properties between Clyde and Alexandra. • Provides good options for expansion of the treated water supply to new areas of subdivision. • Capital cost at $16,529,000 is about $1.5 M more than scenario C but has greater flexibility and reduced operating costs	• Requires the construction of dedicated treated water pipelines from the Muttontown treatment plant to Clyde and Alexandra. • Relies on MICS water storage facility and is dependent on the options that MICS take. • Requires the establishment of a new treatment plant site

Table 18. Scenario C advantages and disadvantages

Advantages	Disadvantages
• Does not require the construction of any pipelines • Could utilise the existing Clyde reservoir site for the Clyde treatment plant • Least capital cost of the three scenarios at $14,090,000.	• Requires the construction and operation of two treatment plants • Highest operating costs of the three scenarios • Relies on MICS water storage facility and is dependent on the options that MICS take. • Does not allow DWSNZ compliant water to be provided to properties between Clyde and Alexandra. • Does not provide good options for expansion of the treated water supply to new areas of subdivision. • Requires the establishment of a new treatment plant site at Alexandra

11 The Ministry of Health Drinking Water Assistance Programme

In 2005, the Government announced a $150m programme to improve the quality of water in small drinking water supplies. The Drinking Water Assistance Programme is administered by the Ministry of Health. To date, funding totalling more than $30m has been provided to upgrade more than 150 water supplies. Funding can be applied for at the end of March and the end of September each year.

The Ministry or Health has prepared criteria for determining which supplies are eligible for funding and how much they should receive. The funding favours supplies that are small and are from areas with high deprivation indices.

Funding is only available for water used for human consumption. Rural supplies which also provide water for household use are eligible to apply for funding however the amount of funding is reduced depending on the percentage of water that is used for horticultural or agricultural purposes.

Drinking water supplies which use a rural agricultural supply as a water source are assessed only on the urban area that is supplied with water for household purposes.

It is worth considering whether the communities of Clyde and Alexandra would be eligible for Ministry of Health funding.

One of the main criteria for determining eligibility for funding is the deprivation index score of the community supplied with drinking water. The deprivation index uses census data to give a score from one to ten for each census meshblock. A score of one indicates a community that has low deprivation and a score of ten indicates a community that has high deprivation. The *Drinking Water Assistance Programme, Criteria for Capital Assistance for Small Community Drinking Water Supplies* requires a community to have a deprivation score of between four and ten to be eligible for funding. The criteria are currently being reviewed and it is likely that the revised criteria will mean that only communities with deprivation scores of between seven and ten will be eligible for funding.

An assessment of deprivation scores indicates that Alexandra has a deprivation score of about 5.4 and Clyde has a deprivation score of about 4.3. Both the Alexandra and Clyde drinking water supplies are currently eligible to apply for Ministry of Health funding to upgrade the supplies. If the likely changes are made to the eligibility criteria, the supplies will not be eligible to apply for funding.

12 Issues and Risks

Some matters regarding the use of Lake Dunstan water and consents held by the MICS are clear and certain, and other matters are unclear and yet to be resolved.

It is clear that the water held in Lake Dunstan is suitable for use as a drinking-water supply after treatment. The level of treatment required for the water to meet the requirements of the DWSNZ is known and the technology is available. There are a number of options available for treatment and the capital and operating costs can be determined to a reasonably accurate level.

It is clear that water treatment at both Clyde and Alexandra will need to be upgraded prior to 2014 when compliance with the Health (Drinking Water) Amendment Act and DWSNZ will be required. These upgrades will need to be undertaken regardless of the availability of water from the MICS. The costs of these upgrades can be determined.

It is expected that there would be sufficient quantity of water available to meet the 26 MLD maximum drinking-water requirement from the MICS consent, though this will only be finalised after the MICS has determined the method and area intended for irrigation, and hence the quantity of water required.

One of the main issues for the CODC is the capital and operational costs of upgrading both the Clyde and Alexandra water supplies. The upgrades are required to comply with the Health (Drinking Water) Amendment Act and the DWSNZ regardless of the opportunities to use water under the MICS consent. However, the options that are selected by CODC will have a bearing on the costs.

A further issue is the extent that both the CODC and the MICS would be involved in a collaborative relationship. There could be benefits in such a relationship, not the least of which would be access for CODC to a satisfactory quantity and quality of source water for drinking-water supply. However, such a relationship would also have risks for both parties.

Uncertainties exist with regard to the decisions that will be taken by the MICS. Any drinking-water supply option that is linked to utilising water taken under the MICS consent is constrained and determined by the decisions that the MICS make.

Formal arrangements will be required between CODC and the MICS to utilise water taken under any MICS consent. It will be necessary to have an ongoing, harmonious, functional and mutually beneficial relationship between the CODC and the MICS. While it appears at this stage that a sufficient quantity of water is available for both irrigation and drinking-water supply, the consented timeframes are long and the resource allowed to be abstracted is finite. Irrigation and drinking-water supply present differing demands for the same resource. It is not known what pressures will be made on the water resource in future times and while a sharing arrangement may be suitable now, when existing consents expire and new consents are sought, attitudes, views and positions may have changed.

Abstraction of water from Lake Dunstan for irrigation will require the construction of a pump station and ongoing pumping costs. It may be necessary for CODC and MICS to share these costs if some of the water is used for a drinking-water supply.

The CODC has a deadline for supplying DWSNZ compliant drinking water by 2014. It is not yet clear what decisions the MICS will make. There is a risk that any collaborative arrangement between CODC and the MICS will affect CODC's ability to meet this deadline. This could be due to delays in the MICS decisions regarding utilisation of the consents, raising capital to build any irrigation scheme it intends to establish, or constructing infrastructure that the CODC may be dependent upon.

There is an issue regarding the need to vary existing resource consents or to seek new consents. The consent process is a lengthy but uncertain process. There is no certainty that any variations to consents would be accepted by the consent authority, or that any new consents would be granted. Variations or new consents may be the subject of notified hearings or would need to have the support of affected parties. If consent variations or new consents were sought, they could be opposed or any decisions appealed to the Environment Court. This could result in delays. There is always an element of risk associated with resource consents though in this situation the main risk is delay. Seeking variations or new consents would not have an impact on any existing consents. If variations or new consents were not granted, any existing consents would not be affected.

There is also a risk to CODC that any delays that are attributed to the MICS may result in cost increases to CODC. As a general rule infrastructure, including water supply, increases in cost over time.

Provision of water to the rural properties and lifestyle blocks located between Clyde and Alexandra and the need to provide the flexibility to supply new subdivisions which may be located in the area is an issue that needs consideration. Two of the proposed scenarios accommodate provision of water to those properties and are more likely to be able to accommodate subdivision. The other scenario is limited in this respect.

With all of the scenarios, it is not certain that the distribution systems of Clyde and Alexandra are configured in a way that will accommodate either a treatment plant in a new location or water inputs from a new location. The most ideal situation for water supply is to have water supplied from a treatment plant to a storage reservoir and from the storage reservoir (by gravity feed) to the distribution system. It is common to have water supplied from a treatment plant, via a distribution system to a storage reservoir. Where this situation occurs, it is necessary to have adequate pipe sizes to allow sufficient flows without excessive pressures when water is being supplied through the distribution system to the storage reservoirs. It would be necessary to undertake modelling of the Clyde and Alexandra distribution zones to determine the most suitable way of providing water into the distribution zones. It may be necessary to install dedicated mains from the treatment plants to existing reservoirs or to construct new reservoirs.

Table 19. Issues and risks

Issue	Risk
Utilising the MICS consent will require a collaborative relationship between the consent holder and the Council.	Requires a formal agreement Decisions taken by MICS may affect Council Ongoing harmonious functional and mutually beneficial relationship required What might be agreed now may not be agreed later
Resource consents	Council could become reliant on consents held by MICS Consent process could cause delays The outcome of the consent process is uncertain.
Delays	The ability of MICS to make decisions, raise capital, install infrastructure may cause delays to Council. Council has a deadline of 2014 to upgrade Clyde and Alexandra water supplies. Delays can result in cost increases.
Provision of water to lifestyle properties between Clyde and Alexandra, and the ability to provide water to possible subdivisions.	Scenarios A and B accommodate this issue. Scenario C does not.
Compatibility of distribution system configurations to having treatment plants or treated water inputs from new locations.	Distribution systems not compatible and would require modification. New mains to reservoirs required.

13 Conclusion

This report has sought to consider a number of questions associated with the possibility of using water from Lake Dunstan taken under a resource consent held by MICS for supply of drinking water, firstly to Alexandra, and secondly to Clyde.

It is clear that water from Lake Dunstan is suitable for supply as drinking water after treatment. There is no evidence that the water contains chemical contaminants which would be of public health concern. Treatment would be required to remove particulate material, including protozoa and to disinfect the water for microbiological contaminants.

A preliminary consideration of the catchment characteristics indicates that a protozoa removal level of 5-log may be required. This cannot be confirmed until a detailed catchment assessment or protozoa monitoring is undertaken and the log removal level agreed with the DWA.

A number of treatment processes have been considered. Conventional treatment and membrane filtration have been identified as the most suitable options.

When all factors are taken into account, it is considered that membrane filtration would be the most suitable option. Conventional treatment while effective is now quite an old concept and technology. Though upgrades of existing plants are regularly undertaken, conventional treatment plants for drinking-water supply have not been installed in New Zealand for some time. Membrane technology, while relatively new, is well tested and proven. A number of membrane treatment plants have been installed in New Zealand recently including large plants at Auckland, Tauranga, Dunedin and Nelson. Smaller plants have recently been installed at Waikouaiti and West Taieri.

For the purposes of this feasibility study, the treatment proposals have been built around a conservative 5-log protozoa removal requirement. Two options for using a membrane filtration treatment plant have been considered, protozoa 5-log removal and chlorination, and protozoa 4-log removal with UV disinfection and chlorination.

It is considered that the most suitable option would be protozoa 4-log removal with UV disinfection and chlorination. This option would allow the installation of 4-log protozoa removal, the maximum log credits that membrane technology has been certified for in New Zealand to date, with a further 3-log protozoa removal provided by UV disinfection. Standby PAC dosing would be required to manage the risk of cyanobacterial contamination. This treatment option would meet the requirements of the DWSNZ.

If it is established that 4-log or 3-log protozoa removal is required, membrane filtration could be used without UV disinfection.

The MICS have a water take resource consent to take water from Lake Dunstan for irrigation and frost fighting. There are a number of ways in which this consent can be utilised to provide drinking water for Alexandra and Clyde. The options for doing this will depend on decisions that MICS make regarding the supply of water for irrigation.

Three scenarios have been provided which outline ways in which the MICS-consented Lake Dunstan water could be utilised for water supply to Alexandra and Clyde. Scenario A would require the construction of a 26MLD treatment plant at Clyde and provision of treated water to Clyde and to Alexandra via a 9 kilometre pipeline at a total cost of approximately $19M. Scenario B would require the construction of 26 MLD treatment plant adjacent to a proposed irrigation storage reservoir at Muttontown and supply of treated water to both Clyde and Alexandra via pipelines at a total cost of approximately $16.5M. Scenario C would require the construction of treatment plants at Clyde, at a cost of approximately $5M, and Alexandra, at a cost of approximately $9M, and a total cost including some pumping capacity of about $14M.

The issues and risks for CODC in using water taken from Lake Dunstan under the MICS resource consent are associated with the need for both parties to have an ongoing and functional working relationship. While this is possible and could be effectively achieved, CODC would become dependent on the MICS' need to modify the existing resource consent and would be subject to any delays due to MICS gaining resource consents, making decisions about how best to utilise water for irrigation, raising capital or installing infrastructure.

A further issue for consideration is the ability of any scenario to provide treated water to lifestyle blocks between Clyde and Alexandra, and the ability of any scenario to provide water to any land that may be developed for housing in the future.

The favoured option is scenario B because it has the lesser cost of the two single treatment plant options. The single treatment plant options have a considerable advantage of having significantly reduced operational costs and greater flexibility to provide water to properties between Clyde and Alexandra. Scenario B would utilise water from an irrigation storage facility and would require a mutually beneficial agreement between the CODC and the MICS.

14 Appendix 1

Turbidity of Clutha River at Alexandra.

Courtesy of Contact Energy and NIWA

Date	NTU
12-Sep-95	10
13-Sep-95	10
14-Sep-95	8
15-Sep-95	7
16-Sep-95	6
17-Sep-95	6
18-Sep-95	7
19-Sep-95	20
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22-Sep-95	10
23-Sep-95	8
24-Sep-95	8
25-Sep-95	6
26-Sep-95	17
27-Sep-95	12
28-Sep-95	15
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30-Sep-95	12
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21-Dec-08	8
22-Dec-08	6
23-Dec-08	5
24-Dec-08	6
25-Dec-08	7
26-Dec-08	6
27-Dec-08	6
28-Dec-08	6
29-Dec-08	6
min	0
max	168
mean	4

15 Appendix 2

Otago Regional Council Dataset

Courtesy of Otago Regional Council

SOURCE	SITE_NAME	easting	northing	SAMPLE_ID
Lake Dunstan	Dead Mans Point	2212200	5567700	OTA970809

SITE ID	SAMPLE DATE	COLLECT TIME	E. coli mpn/100ml	pH (Lab) pH	pH (Field)	Turbidity NTU
OTA7520643	23-Jul-97	11:40		7.8		0.3
OTA7520643	19-Sep-97	13:00		7.9		0.6
OTA7520643	14-Nov-97	09:20		8		1.5
OTA7520643	30-Jan-98	10:15		7.9		1.8
OTA7520643	26-Mar-98	00:00		8		1.5
OTA7520643	09-Jun-98	13:00				0.7
OTA7520643	11-Aug-98	12:20		7.9		
OTA7520643	06-Dec-98	09:58	1	8.2		0.5
OTA7520643	25-Feb-99	13:09	10	8.6		0.5
OTA7520643	23-Apr-99	10:25	1	7.9		0.5
OTA7520643	15-Jun-99	13:25	2	7.8		0.9
OTA7520643	16-Aug-99	13:20	4	7.9		0.7
OTA7520643	16-Dec-99	12:00	4	8.5		6.2
OTA7520643	08-Feb-00	09:45	0.5	8		1.8
OTA7520643	18-Apr-00	13:10	2		7.8	0.5
OTA7520643	14-Jun-00	12:00	5	8.1		5.4
OTA7520643	17-Aug-00	13:45	0.5	8.7		1.6
OTA7520643	16-Oct-00	11:58	0.5	8.2		2.2
OTA7520643	04-Dec-00	12:15	0.5	8.7		0.76
OTA7520643	07-Feb-01	12:00	1	8.6		0.68
OTA7520643	05-Apr-01	13:00	0.5		8.47	0.46
OTA7520643	20-Jun-01	13:30	2	7.4		0.65
OTA7520643	28-Aug-01	13:20	0.5	8.1		1.09
OTA7520643	17-Oct-01	12:46	1	7.6		1.45
OTA7520643	04-Dec-01	13:00	6	8.3		0.77
OTA7520643	25-Feb-02	12:30	2	8.1		0.48
OTA7520643	18-Apr-02	12:45	2	8.1		0.69
OTA7520643	27-Jun-02	14:50	2	7.4		0.54
OTA7520643	22-Aug-02	13:20	0.5	7.69		3.5
OTA7520643	17-Oct-02	12:30	1	7.92		0.85
OTA7520643	04-Dec-02	13:10	0.5		7.81	0.45
OTA7520643	12-Feb-03	11:20	1		7.89	0.35
OTA7520643	15-Apr-03	12:25	3	8.1		0.3
OTA7520643	18-Jun-03	12:05	1	7.88		0.35
OTA7520643	27-Aug-03	12:35	0.5	7.84		0.65
OTA7520643	08-Oct-03	11:15	0.5		8.14	0.6

OTA7520643	16-Dec-03	11:30	0.5	8.25		0.4
OTA7520643	21-Jan-04	08:50	1			
OTA7520643	17-Feb-04	11:15	1		8.23	0.4
OTA7520643	14-Apr-04	12:15	0.5	7.9		0.4
OTA7520643	23-Jun-04	13:50	0.5	7.5		0.5
OTA7520643	18-Aug-04	12:30	2	7.62		4.4
OTA7520643	05-Oct-04	11:30	0.5		8.02	0.35
OTA7520643	09-Dec-04	12:15	0.5		8.03	0.5
OTA7520643	15-Feb-05	11:15	4		7.62	0.5
OTA7520643	27-Apr-05	12:00	11		7.87	0.4
OTA7520643	16-Jun-05	12:15	0.5	7.51		0.4
OTA7520643	03-Aug-05	12:30	1		7.51	0.33
OTA7520643	18-Oct-05	10:55	0.5		7.77	0.35
OTA7520643	08-Dec-05	13:20	4		8.24	1.1
OTA7520643	09-Jan-06	12:30	10			
OTA7520643	07-Feb-06	12:05	3			
OTA7520643	02-Mar-06	11:10	2	7.3		0.88
OTA7520643	12-Apr-06	10:40	1		7.93	0.72
OTA7520643	15-Jun-06	11:20	0.5		8.14	0.44
OTA7520643	16-Aug-06	13:25	0.5		8.36	0.55
OTA7520643	18-Oct-06	12:50	0.5	7.9	8.5	0.93
OTA7520643	05-Dec-06	12:40	14		7.97	5.3
OTA7520643	16-Jan-07	13:55	1			
OTA7520643	14-Feb-07	13:00	2		8.58	0.67
OTA7520643	14-Feb-07	13:00	1			
OTA7520643	15-Mar-07	10:45	0.5			
OTA7520643	10-Apr-07	13:30	2		8.73	0.45
OTA7520643	19-Jun-07	13:55	2		8.09	0.43
OTA7520643	21-Aug-07	00:00	1	7.5		1.19
OTA7520643	16-Oct-07	13:35	0.5	7.9		4.42
OTA7520643	11-Dec-07	13:30	1		8.35	0.39
OTA7520643	12-Feb-08	14:00	1			0.42
OTA7520643	29-Apr-08	14:55	1		8.33	0.4
OTA7520643	17-Jun-08	13:40	1		8.13	0.67
OTA7520643	14-Aug-08	13:50	2		7.47	0.42
OTA7520643	20-Oct-08	13:40	1		8.62	0.48
OTA7520643	15-Dec-08	13:55	4	7.9	8.25	0.69
OTA7520643	18-Feb-09	13:20	0.5		8.8	0.39
OTA7520643	08-Apr-09	14:15	28	7.6	8.56	2.34
OTA7520643	16-Jun-09	15:10	4	7.6	8.18	1.5

OPUS